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SCYPHOMEDUSÆ

BY

G. STIASNY, D.Sc.

(*Conservator of the Rijksmuseum van Natuurlijke Historie and Privaat-docent at the University, Leiden, Netherlands*)

WITH ONE PLATE, FOURTEEN TEXT-FIGURES AND TWO MAPS

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CONTENTS.

PAGE

INTRODUCTION 203

The Arabian Sea a nearly unexplored area as regards the Scyphomedusæ—Previous records from this sea, the Indian Ocean and the Red Sea—Comparison with the list of the "John Murray" medusæ—The material discussed—Importance of the catches—Geographical distribution of the Scyphomedusæ in the Arabian Sea.

SYSTEMATIC ACCOUNT 210

Tamoya alata (Reynaud) 210

Chiropsalmus quadrigatus Haeckel 213

Periphylla hyacinthina Steenstrup 218

Nausithoë punctata Kölliker 220

Atolla wyvillei Haeckel 221

Pelagia noctiluca (Forskål) 223

Sanderia malayensis Goette 225

Aurelia maldivensis Bigelow 227

Cephea sp. 229

Netrostoma cœrulescens Maas 229

Crambionella orsini (Vanhoeffen) Stiasny 231

SOME REMARKS ON THE RELATION OF THE HYDROGRAPHY TO THE DISTRIBUTION OF THE SCYPHOMEDUSÆ IN THE ARABIAN SEA 237

LIST OF REFERENCES 240

INTRODUCTION.

IT is certainly very astonishing that a region so much frequented as the Arabian Sea is still unexplored with regard to animals so large and striking as the Scyphomedusæ. Prior to the John Murray Expedition no other expedition has explored these waters, though occasionally records have been given of large medusæ from this part of the Indian Ocean. Our knowledge of the medusæ of the Arabian Sea is mainly due to E. T. Browne, who

reported on collections from the Maldives and Laccadives (1905), the Pearl Oyster Banks of Manaar (1905), the Okhamandal coast of Kattiawar (1916), and of the "Sealark" from the southern parts of the Arabian Sea (1916). Bigelow (1901–4) has given a short report on a collection from the Maldives. More extensive is the memoir of Vanhoeffen (1903) on the collections of the "Valdivia"; the Deutsche Tiefsee Expedition, however, examined this part of the Indian Ocean somewhat superficially. Chun (1896) has described some new medusæ from the waters off Zanzibar. But this is the full extent of our knowledge. It is, therefore, easily understood that, although in the catches of the John Murray Expedition there are no new forms and the number of species collected is not large, the material gathered in an area so poorly explored is important from the point of view of geographical distribution.

The western part of the Indian Ocean has been much better explored with regard to the Scyphomedusæ than the eastern part. Here the medusan fauna of Madras, Calcutta and the Malayan Archipelago has recently been studied respectively by Menon, Rao and the author himself, and long lists of Scyphomedusæ have been recorded from these waters.

I give below a list of the species collected by the John Murray Expedition :

	Number of specimens.
Order CHARYBDEIDÆ :—	
Family CHARYBDEIDÆ :	
Tamoya alata Reynaud*	4
Family CHIRODROPIDÆ :	
Chiropsalmus quadrigatus Haeckel*	1
Order CORONATÆ :—	
Family PERIPHYLLIDÆ :	
Periphylla hyacinthina Steenstrup	237
Family ATOLLIDÆ :	
Atolla wyvillei Haeckel	33
Family NAUSITHOIDÆ :	
Nausithoë punctata Kölliker	1
Order SEMÆOSTOMEÆ :—	
Family PELAGIDÆ :	
Pelagia noctiluca Forskål	115
Sanderia malayensis Goette	6
Family ULMARIDÆ :	
Aurelia maldivensis Bigelow	9
Order RHIZOSTOMÆ :—	
Family CEPHEIDÆ :	
Cephea sp.	2
Netrostoma cœrulescens Maas*	1
Family CATOSTYLIDÆ :	
Crambionella orsini (Vanh.) Stiasny*	17
Total	426

* A new record for the Arabian Sea.

In addition the following stages of development (young and older ephyræ and later stages) were sorted out from the plankton samples :

Pelagia noctiluca Forskål . . . . . 10 specimens.
Periphylla hyacinthina Steenstrup . . . . 1 specimen.
Sanderia malayensis Goette . . . . . 27 specimens.

Of the 426 specimens caught more than half are referable to *Periphylla hyacinthina* (237 specimens in all ; 86 from Station 35, 59 from Station 186, and 55 from Station 193). Then follows in respect of numbers *Pelagia noctiluca* with 115 specimens (69 specimens from Station 87). Many fewer specimens were caught of *Atolla wyvillei* (33) and *Crambionella orsini* (17). The remaining species are represented in the catches by a few specimens only.

The following forms are remarkable :

Chiropsalmus quadrigatus : The single complete specimen, although its different organs are partially torn away or removed, was available for a more thorough study of the anatomy of this rare medusa, especially of the gastric pouches, than has been made previously.

Sanderia malayensis : Besides some very beautiful adult specimens, several young stages of development could be studied, these being the first stages of development of this medusa that have ever been recorded.

Crambionella orsini : This species, represented in the catches by numerous well-preserved specimens with fresh colours, could be studied with regard to variation of coloration and be compared with the other known species of this genus. In this case I have been able to settle certain systematic questions.

The importance of the present collection becomes evident by a comparison of the lists of the previous records of Scyphomedusæ in the Indian Ocean and the Arabian Sea with the list of the medusæ caught by the John Murray Expedition.

Previous Records of Scyphomedusæ in the Indian Ocean.*

Chun (1896), from Zanzibar :—
Pelagia panopyra Pér. and Les.
Aurelia colpota Brandt.
Crambessa stuhlmanni Chun.
C. viridescens Chun.
Mastigias siderea Chun.
Cassiopea andromeda var. *zanzibarica* Chun.

Bigelow (1901–04) from the Maldive Islands :—
Aurelia maldivensis Bigelow.
Nausithoë punctata Kölliker.

Browne (1905*a*) from the Laccadive and Maldive Archipelagoes :—
Pelagia sp.
Aurelia aurita var. *colpota* Brandt.
A. solida Browne.
Cassiopea andromeda var. *maldivensis* Browne.
Netrostoma cœrulescens Maas.

* The names of the species are given here as written in the original communications.

Browne (1905*b*) from the Gulf of Manaar :—

Charybdea sp.
Nausithoë punctata Kölliker.
Pelagia sp.
Crambessa sp.

Browne (1916*b*), from the Okhamandal Coast, Kattiawar :—

Cassiopea andromeda var. *maldivensis* Browne.

Browne (1916*a*), from the "Sealark" collection, between Chagos, Mauritius and the Seychelles :—

Charybdea sp.
Nausithoë punctata Kölliker.
Atolla wyvillei Haeckel.
Pelagia panopyra Pér. and Les.
P. flaveola Eschscholtz.
Pelagia sp.
Cassiopea andromeda var. *maldivensis* Browne.

Vanhoeffen (1903), from the collection of the "Valdivia" Expedition :—

**Atolla verrilli* Fewkes . . .	Indian Ocean.
**A. valdiviæ* Vanhoeffen . . .	Indian Ocean.
Periphylla regina Haeckel . .	Indian Ocean (tropical parts).
P. dodecabostrycha Brandt . .	Indian Ocean.
P. hyacinthina Steenstrup . .	Coast of Somaliland.
Periphyllopsis braueri Vanhoeffen .	Between New Amsterdam and Cocos Island.
Nausithoë punctata Kölliker . .	Gulf of Aden and East of Ceylon.
N. rubra Vanhoeffen . . .	West of Ceylon.
Palephyra indica Vanhoeffen . .	†Gulf of Aden.
Atorella subglobosa Vanhoeffen . .	†Between Seychelles and Dar es Salaam.
Pelagia phosphora Haeckel . .	Between Ceylon and East Africa.
Sanderia malayensis Goette . .	Gulf of Aden.
Chrysaora fulgida Reynaud . .	Algoa Bay.
Poralia rufescens Vanhoeffen . .	Between Koningin Emma haven and Siberut.
Aurelia aurita Linn. . . .	†Koningin Emma haven, between Maldives and Chagos islands, near the coast of Somaliland and the Red Sea.
Cephea cœrulea Vanhoeffen . .	Dar es Salaam.
Mastigias papua Lesson . . .	Koningin Emma haven.

Very much richer are the lists given by Menon of species from Madras and by Rao of the "Investigator" collections from the Bay of Bengal and the Laccadive Sea.

Menon (1930), from Madras :—

Charybdea madraspatana Menon.
Tamoya sp.
Chiropsalmus buitendyki Horst.

* *Atolla verrilli* and *valdiviæ* are synonyms for *A. wyvillei* ; for localities see the Map.
† Not indicated in the Map.

Nausithoë punctata Kölliker.
Pelagia noctiluca Pér. and Les.
Dactylometra quinquecirrha Agass.
Cyanea purpurea Kishinouye.
Aurelia solida Browne.
Cassiopea andromeda var. *malayensis* Maas.
Cephea sp.
Netrostoma cœrulescens Maas.
N. setouchianus Kishinouye.
Mastigias albipunctata Stiasny.
Lorifera lorifera (Haeckel).
Lychnorhiza malayensis Stiasny.
Crambionella orsini (Vanh.) Stiasny.
C. stuhlmanni (Chun).
Acromitus flagellatus (Haeckel).
Lobonema mayeri Light.
Lobonemoides robustus Stiasny.
Rhopilema hispidum Maas.

Rao (1931), from the coasts of India and Burma :—
Periphylla hyacinthina Steenstrup.
Atolla wyvillei Haeckel.
Tamoya alata Reynaud.
Tamoya sp.
Chiropsalmus quadrumanus Agass.
Pelagia noctiluca Forskål.
Chrysaora helvola Brandt.
Cyanea capillata var. *nozakii* Kishinouye.
Aurelia aurita Lam.
A. solida Browne.
Cassiopea (?) *frondosa* (Pallas) Lam.
C. andromeda var. *maldivensis* Browne.
Netrostoma typhlodendrium Schultze.
Mastigias occellata (Modeer).
M. albipunctata Stiasny.
M. papua var. *sibogæ* Maas.
Mastigias sp.
Versura anadyomene (Maas).
Thysanostoma thysanura (Haeckel).
Acromitus flagellatus (Haeckel).
A. rabanchatu Annandale.
Crambionella annandalei Rao.
Lobonema smithii Mayer.
Lobonemoides sewelli Rao.
Rhopilema hispidum Maas.

From the above lists we see that certain species have been caught by the John Murray Expedition in the Arabian Sea that are new for the fauna of this region (viz. *Tamoya*

alata, *Chiropsalmus quadrigatus*, *Netrostoma cœrulescens* and *Crambionella orsini*), and that, on the contrary, many very typical forms, recorded very regularly from the waters of the eastern half of the Indian Ocean, are not represented in the collection. We miss in the first place such very common medusæ as *Dactylometra quinquecirrha*, *Mastigias papua*, *Crambione mastigophora* and various species of the genera *Acromitus* and *Catostylus*, all true representatives of the fauna of the Bay of Bengal and the Malayan Archipelago; and it is a striking fact that in the catches made by the expedition not a single specimen could be found of the very common *Cassiopea andromeda*, that is known from the Red Sea and has been recorded previously in the Arabian Sea from Zanzibar, from Kattiawar and from the waters of the Maldive Archipelago. The absence of this medusa, otherwise so typical for all tropical shallow seas, may perhaps be due to the fact that the western coasts of the Arabian Sea are mostly rocky, that there are often high, vertical or in some places even overhanging cliffs, that there are very few lagoons and mangrove-swamps, and that the shelf in general is very narrow and drops rather abruptly into deep waters.*

Very striking, on the other hand, is the appearance of *Crambionella orsini*, in the Gulf of Oman, this medusa having been found, hitherto, exclusively in the waters off Madras and only once (near Assale) in the Red Sea. It was, therefore, not to be expected in this area.

If we now look at the Chart showing the geographical distribution of the "John Murray" medusæ (Map I), the first impression that we get is that the localities are by no means evenly distributed over the Arabian Sea. We see at a glance that there are two large concentrations of localities, one in the Gulf of Oman and the other in the Gulf of Aden, and two smaller "nests", one in the waters off Zanzibar and the other near Cape Guardafui. In the eastern and central parts of the Arabian Sea there are very few localities—seven only in the section Bombay–Mombasa. This is, however, not at all surprising; the open sea is not the proper habitat for these rapacious animals, which, in general, prefer the more nutritive waters of the shores and the mouths of rivers. It is, however, rather astonishing that so few specimens of medusæ were caught in the waters off Zanzibar, near the Maldives and in the south of our area. This may be due to bad weather and heavy seas (monsoon), or to the collecting having been done at the wrong season of the year (*vide* Browne, 1916*b*, p. 151 and footnote; Sewell, 1935, p. 6 and this report, p. 220). From all these localities previous expeditions collected many more specimens of medusæ than did the John Murray Expedition. As I have shown in my report on the medusæ collected by the "Snellius" Expedition (1935), collections made by expeditions do not always give a good impression of a fauna, and it has occurred more than once that just the most characteristic components of a fauna may be absent from the lists. It is the conviction of the author that several species that were either not collected by the John Murray Expedition at all, or are represented by one or a few specimens only, are more abundantly represented in these waters than the records of their occurrence might indicate, *e. g. Nausithoë*, *Cassiopea*, etc.

Let us consider now the previous records in the two charts given by Vanhoeffen in 1891 and 1909 representing the geographical distribution of the Scyphomedusæ all over the world. We see that in the Arabian Sea there are numerous localities of *Nausithoë punctata*, which is distributed over the whole Indian Ocean, and a few

* It must also be borne in mind that the object of the Expedition was essentially the exploration of the deeper waters, and in consequence the exploration of the plankton, especially that of the upper levels, was omitted from the programme of work to be undertaken.—Editor.

catches of *Periphylla* near Zanzibar and in the Gulf of Aden. (I cannot understand why Vanhoeffen omitted from his map of 1909 the localities of the Scyphomedusæ of the "Valdivia" Expedition, that he himself reported on in 1903.) In my transparent map (Map II), nearly all localities of Scyphomedusæ recorded in the previous reports are represented (with the exception of a few species caught only once in this region). We find in the whole northern part of the Arabian Sea between Arabia and British India the same large empty space as is shown in the charts of Vanhoeffen, with the exception of one single locality (*Cassiopea andromeda*, Browne, 1916). A few catches are recorded from the Gulf of Aden (*Periphylla*, *Atolla*, *Nausithoë*). The central part of the Arabian Sea is entirely empty. Previous localities are, however, abundant in the area between the Laccadives (Minikoi) and the Chagos Archipelago ; here we find recorded numerous catches of *Aurelia*, *Pelagia* and *Nausithoë* in an area where the John Murray Expedition collected almost nothing. There are a few catches between the Seychelles and Zanzibar (*Nausithoë*, *Periphylla* and *Atolla*). The waters off Zanzibar, however, appear to be relatively rich in different species of Scyphomedusæ, but, apart from *Nausithoë* and *Aurelia*, the records are for the most part of a single or very few specimens of very rare species. The John Murray Expedition here collected quite different forms, and particularly remarkable is the chain of localities along the Somali coast to Cape Guardafui of *Pelagia*, *Aurelia*, *Periphylla* and *Atolla*. On the whole we find that the previous localities occur either exclusively in the southern part of the Arabian Sea or are arranged peripherally around the empty central area.

If we observe both maps simultaneously, the progress of our knowledge of the distribution of Scyphomedusæ in the Arabian Sea afforded by the John Murray Expedition becomes evident. Previous records and the localities of the John Murray Expedition form excellent supplements to each other, so that the whole area appears now to have been explored, with the exception, perhaps, of the area between the Laccadives and Bombay, in which we have only a single record of *Periphylla hyacinthina* and two of *Atolla wyvillei*.

The scyphomedusan fauna of the eastern part of the Indian Ocean, and to a still higher degree that of the waters of the Malayan Archipelago, is very much richer. In conformity with the statements made by Ekman (1935, pp. 46–47), it can be said that the further we pass westwards from the Malayan Archipelago with its abundant Scyphomedusæ, the medusan fauna becomes progressively poorer, and its character more and more different.

A comparison of the scyphomedusan fauna of the Arabian Sea with that of the Red Sea is at present almost impossible. It is much to be regretted that the Red Sea must still be regarded as almost unexplored in this respect. The collections of the single large expedition that explored the whole area, namely that of the "Pola", have never been studied and, for the rest, there are but very few records of Scyphomedusæ from this sea (Vanhoeffen described a few medusæ from Assab, and Keller studied the variability of a species of *Cassiopea* from a locality, not indicated, in the southern part of the Red Sea ; all other records are from northern parts [Browne, Haeckel, Mayer and the author]). As far as we know, the main representatives are *Pelagia*, *Aurelia*, *Cassiopea*, *Sanderia*, *Cephea* and *Mastigias*. There is, however, no doubt that the scyphomedusan fauna of the Red Sea is even poorer than that of the Arabian Sea. It is, of course, a great pity that the John Murray Expedition, when passing this region twice, had no opportunity of

collecting here.* I believe, however, that not many medusæ are to be expected in the southern part of the Red Sea. Sewell (1935, p. 8) writes, " at depths greater than that of the entrance channel, namely some 100 metres, there is an almost complete absence of animal life ". This is, however, certainly not the case at the surface.

The material is, on the whole, in a good state of preservation. The specimens of *Sanderia malayensis* are extremely beautiful, and those of *Crambionella orsini* have maintained not only their original shape, but their vivid colours too. The specimens of *Periphylla* and *Atolla*, however, from greater depths, are for the most part deformed and their colours have faded ; I found those in the jars to be almost transparent, lying in a brown fluid, the pigment having dissolved out.

I take the opportunity of expressing my best thanks to Lieut.-Col. R. B. Seymour Sewell, the leader of the expedition, not only for much valuable information and advice, but also for the revision of the text of my manuscript. I am very much obliged to Dr. W. T. Calman, former, and Mr. Martin A. C. Hinton, present Keeper of the Zoological Department, British Museum, London, for the interest they have taken in these studies and for the trouble that both took to facilitate them. My thanks are also due to Mr. H. van der Maaden, Katwyk aan Zee, for his valuable assistance in various respects in preparing this report. Finally, I render my best thanks to Mr. H. Cornet, preparateur aan het Ryksmuseum van Natuurlyke Historie, Leiden, for all his trouble in making the photographs for Plate I of this report.

SYSTEMATIC ACCOUNT

Order CHARYBDEIDEA Poche, 1914.

(= CHARYBDEIDÆ Gegenbaur, 1856, CUBOMEDUSÆ Haeckel, 1879.)

Family CHARYBDEIDÆ Haeckel, 1879.

Genus *Tamoya* Fritz Müller 1859.

Tamoya alata (Reynaud). (Text-figs. 1, 2 and 3*a*, *b*.)

References :

Charybdea alata var. *grandis* Agassiz and Mayer, A. G. Mayer, 1910, p. 511.
Tamoya alata Reynaud, T. Uchida, 1929, pp. 172–180, figs. 87–88.
Tamoya alata Reynaud, H. S. Rao, 1931, pp. 27, 28.
Tamoya alata Reynaud, G. Stiasny, 1934, pp. 341, 342.
Tamoya alata Reynaud, G. Stiasny, 1935, pp. 10, 11.

OCCURRENCE :

1. Station 43, Arabian Coast, near Kuria Muria Islands ; 28.x.33. Hand-net ; surface.
2. Station 65, Gulf of Oman, 21.xi.33. " Came up on hydrographic wire above water-bottle."

* This area was deliberately omitted from the programme of the Expedition, as it was anticipated that the exploration of this region will be undertaken by the Government of Egypt in the near future.—EDITOR.

3. Station 95, Central area of Arabian Sea, 18.xii.33. 2-metre diam. tow-net, 984–430 metres (1400 metres of wire out).
4. Station 172, Central area of Arabian Sea, east of Cape Guardafui, 29.iv.34. 1-metre diam. tow-net, 200–0 metres (510 metres wire out).

Distribution.—*Tamoya alata* has been recorded by Rao (1931) from the Bay of Bengal (" a fairly large series of specimens "), and by Menon (1930) from the waters off Madras. The species is common in the Malay Archipelago (*vide* my " Discovery " Report, 1934, p. 342). It has not, hitherto, been recorded from the western part of the Indian Ocean, but most probably the so-called "'*Charybdea* sp." mentioned by Browne (1905 and 1916) are identical with it.

The John Murray Expedition captured two specimens in the central part of the Arabian Sea, one off the south coast of Arabia and a fourth in the Gulf of Oman :

1. A very large specimen, well preserved, without, however, stomach and manubrium. The surface of the ex-umbrella is covered all over with large round nematocyst-clusters, which are highest and most numerous at the apex. Velarium with 13–15 velar canals, not anastomosing. Gonads complexly folded. Colour whitish-yellow. (Measurements given in the following table.)
2. Specimen fallen to pieces ; must have been somewhat larger than the first. Without gonads. Colour whitish, transparent. Pedalia 60 mm. long by 40 mm. broad.
3. Specimen not so well preserved as the first ; 12–13 velar canals, not anastomosing. Gonads feebly developed. Colour yellowish.
4. Specimen fairly well preserved, with very large nematocyst-clusters in the apical region. Gonads feebly developed. Gastric cirri distinctly visible. Colour pinkish.

Table of Measurements.

(All measurements are in millimetres.)

Specimen.	1.	3.	4.
Height of the bell	240	175	75
Breadth at the apex	85	65	25
,, in the middle	110	80	40
Length of pedalia	55	52	22
Breadth of pedalia	30	27	8
Distance of sensory-niche above margin	40	28	12
Average diameter of tentacles (most torn away)	3	5	5
Longest tentacle	1000 ?	80	22
Breadth of velarium	35	26	7

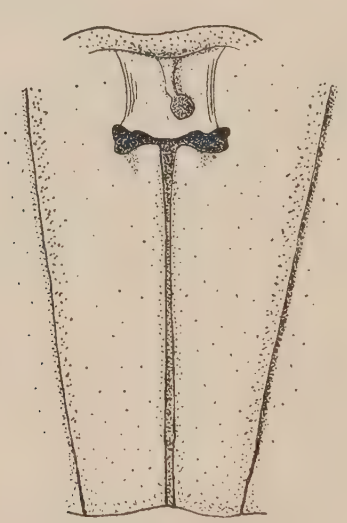
In spite of differences in the sculpture of the ex-umbrella all these specimens belong, I believe, to one very variable species, because they all agree in the form of the dumb-bell-shaped opening of the sensory-pit (the importance of this character has been explained by me in a previous paper (1919, p. 51). The first specimen, from Station 95, is remarkably large : Uchida (1929, p. 173) gives the maximum size of Japanese specimens as 220 mm.

The gonads in this specimen are " complexly folded " indeed, but are extremely brittle, and fall to pieces at the slightest touch with a pencil.

I give some figures and details of structure, taken from the large, best preserved specimen, since this extremely brittle medusa is but rarely obtained in a good state of preservation.

Velarium (Text-fig. 1).—The velar canals are very long and broad ; they are finely lobed and do not anastomose. Their shape is quite different from that figured by Uchida

Text-fig 1.



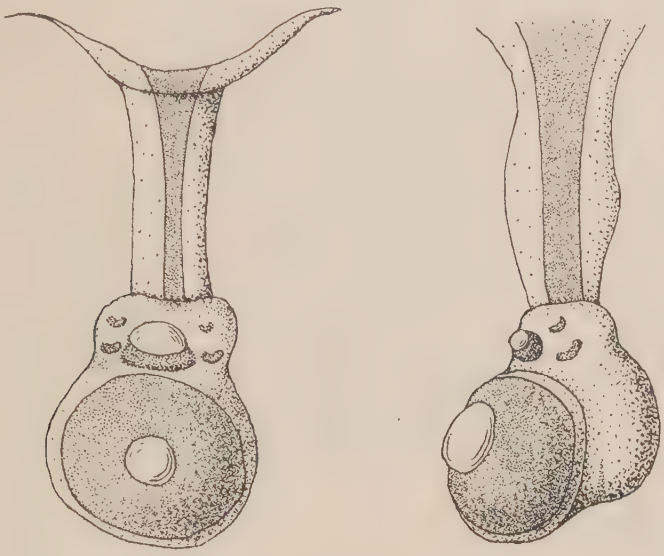
Text-fig. 2.

(1929, fig. 85) from a very young specimen, where they are mostly short and narrow, and agree with the figure given by me (1921, fig. 9). As the number and shape of the velar canals are, however, according to Uchida, subject to great changes during development, I do not believe that these characters merit so high a taxonomic value as has been attributed to them hitherto.

Sensory pits (Text-fig. 2).—The 4 sensory organs are lodged in a groove on a broad thickening of the jelly. The pits are of a very characteristic shape. In Uchida's figures (1929, figs. 81*a* and *b*) they are only faintly indicated. The opening of the pit is dumb-bell shaped, constricted in the middle, with two larger openings at the sides. The border

of the upper lip of the squama rhopalaris is wavy. The niche itself lies at a distance of about 40 mm. from the margin of the umbrella, and is separated from the neighbouring deeper and flatter parts of the ex-umbrella by deep and long furrows; these at their commencement run straight, but later, as they pass upwards, diverge and vanish slowly in the jelly of the umbrella. Beneath the sensory pit a small straight gully runs from the base of the niche to the border of the velarium.

The sensory organs (Text-fig. 3*a*, *b*).—These are very large. The median eye is globular with a large lens in the centre and is pigmented a very dark bluish-brown. The second eye lies above the first and is much smaller, but also has a small lens and a brown pigment mantle. Both pairs of crescent-shaped pigment-spots on the sides are brownish in colour.



a *b*

Text-fig. 3.

The concretion in the terminal knob is very large, strongly vaulted forwards and backwards, and also bears a faint crescent-shaped pigment-spot (Text-fig. 3*b*).

Tamoya alata being a typical surface medusa, the depths of the hauls, 984–430 metres and 200–0 metres, are remarkable. In the case of the latter haul at Station 172 and the specimen that was caught on the hydrographic wire at Station 65, these may have come from quite near the surface; but the same cannot be said of the specimen from Station 95, as at this station the self-closing mechanism was used, so that the net was not fishing on the way to the surface.

Family Chirodropidæ Haeckel, 1879.

Genus *Chiropsalmus* L., Agassiz, 1862.

Chiropsalmus quadrigatus Haeckel. (Text-figs. 4–9.)

References:

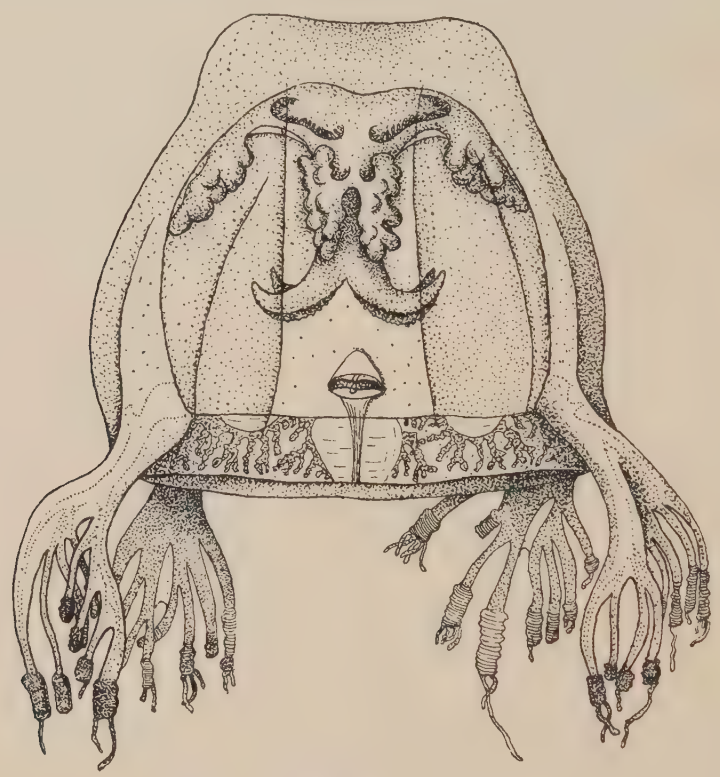
E. Haeckel, 1879, p. 447.
A. G. Mayer, 1910, p. 516, fig. 331A–E; 1917, pp. 190–191, fig. 4A–E.
G. Stiasny, 1922*b*, p. 517.

Occurrence :

Station 146, Lagoon of Horsburgh Atoll, Maldive Archipelago, 2.iv.34. Otter trawl, 37 metres.

1 specimen, together with 1 specimen of the fish *Leiognathus* (= *Equula*) *equulus* (Forsk), determined by Dr. F. P. Koumans.

Distribution.—This medusa has not hitherto been recorded from the western part of the Indian Ocean. It is not rare in Philippine waters (Mayer, Light). Haeckel records one specimen from Rangoon (*vide* my paper, 1922*a*, p. 517) ; another is mentioned by me from the Malayan Archipelago (*ibid.*).



Text-fig. 4.

Descriptive Notes.—This medusa is poorly known. There exists only a short diagnosis and description by Haeckel (1879, p. 447) without figures, and a somewhat more detailed account by Mayer (1910, p. 516, and 1917, p. 190), both these papers having identical figures (side-view and details). Between these two descriptions there are certain discrepancies, to which Thiel (1927, p. 13) has already called attention, and he doubts whether the two accounts refer to the same species. I, however, believe that they do. I had the opportunity of examining the type-specimen of Haeckel's medusa in the collection of the Zoological Museum, Copenhagen (*vide* my paper, 1922*a*, p. 517), but was unable to add anything to Haeckel's description as the specimen is badly damaged and all the inner parts have vanished. The medusa is so fragile that it is very rarely captured undamaged and, moreover, falls to pieces at the slightest touch. The present specimen is not intact. The most important character of the species, namely the strangely formed gastric saccules, are, however, so distinctly described and figured by Mayer and are so clearly visible in

the present specimen that it was possible to identify both. I believe that the specimen is identical with *quadrigatus*, although there are some differences.

The umbrella with the pedalia is well preserved, but several of the inner parts, the manubrium with the stomach, the gastric saccules, etc., are partly detached and are hanging down, while most of the tentacles have been torn away ; but all organs are present and in a good state of preservation. I have, therefore, taken the opportunity of augmenting, as far as possible, the poor descriptions of previous authors, and have given a rather schematic sketch of the animal (Text-fig. 4, side view) ; it must, however, be recognized that this is nothing more than a reconstruction of the entire medusa and a recombination of the separated internal organs.

Height 70 mm., breadth 80 mm. at the level of the velarium ; rather a small specimen, Light having recorded some of 200 mm. size. The *bell* is nearly cube-shaped, with rounded edges, evenly rounded at the apex and a little narrower there than in the middle. Surface of the bell perfectly smooth, the jelly thick and cartilaginous. Side-pillars very strong,

Text-fig. 5.

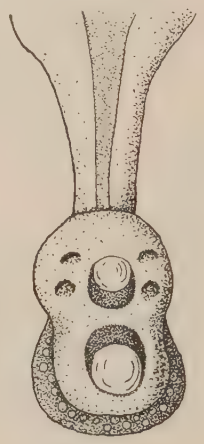
vaulted, pyramidal in shape with rounded ridges, bounded on both sides by deep furrows, merging gradually into the pedalia. Lateral sides of the bell rectangular, vaulted, separated from the side-pillars by a broad, plain, wedge-shaped zone. The *velarium* appears to have hung vertically instead of forming a horizontally-stretched diaphragm, supported by 4 bracket-like frenulæ, ± 18 mm. broad ; and there are 12 to 18 larger or smaller, finely ramified but not anastomosing velar canals in each quadrant (Text-figs. 4, 5).

The 4 *niches of the sensory organs* (Text-fig. 6) lie upon a strongly protruding pyramid-shaped thickening of the jelly, about 22 mm. above the velar margin. The niche itself is a broad slit, somewhat narrowed by the projecting under-lip, but with only one opening that is not dumb-bell-shaped as figured by Mayer (1910, fig. 331, middle). Each *sense-club* (Text-fig. 7) bears, besides a large entodermal ball-shaped, terminal abaxial concretion on its inner side, 2 median eyes (one large, the other smaller), each with a prominent convex lens and a pigment mantle, and on each side two smaller crescent-shaped pigment-spots of brownish-yellow colour. The *pedalia* (Text-figs. 4 and 8) arise inter-radially in the middle of the height of the bell. They are ± 45 mm. long, scythe-shaped, somewhat twisted, and continued as a thinner pedicle, bearing two wings in the distal part ; the pedicle measures 18 mm. in length, the wings, when outstretched, ± 45 mm. broad. The wings are separated from each other by a deep notch, and each wing bears 4 symmetrically arranged, stiff finger-shaped tentacles, the uppermost being the longest (± 22 mm.) and the lowest the shortest. The pedalia are laterally compressed, quite transparent, with an

internal broad whitish vessel that bears a small horn-like, upwardly-directed projection on its outer side above the velarium. To each tentacle there runs a narrower whitish canal.

The *tentacles* are in their proximal parts laterally compressed, with sharp edges, transparent; distally they are somewhat thickened, cylindrical, opaque and covered all over the surface with numerous nematocyst-bearing rings. The distal end of the tentacles is rather puzzling and each tentacle is different; it may be plainly truncated without any appendix, or be provided with 1, 2, 3 or 5 shorter or longer, thicker or thinner, thread-like filaments. I have never before seen a similar appearance, but I do not believe that I am dealing here with an artefact.* Mayer's description is, however, somewhat confusing; he speaks of " about 5 to 9 finger-shaped terminal projections, which give rise to an equal number of long flexible hollow tentacles ". In his figure the latter, however,

TEXT-FIG. 6.



TEXT-FIG. 7.

are not to be seen; here every projection bears only a single long, strong tentacle, the end of which is simple and thread-like. Mayer, I believe, must have seen something similar to what I have found.

The *mesenteries* are transparent, narrow, scythe-shaped membranes.

The *stomach* (Text-fig. 4) is flat and wide. The manubrium is 35 mm. in length, prismatic, with 4 sharp perradial edges and 4 strongly developed, simple, slightly folded lips, feebly bent upwards.

The whitish *gastric cirri*, very numerous, fusiform, simple, unbranched, ± 5 mm. long, are arranged in several inter-radial arched rows of ± 35 mm. length, lying along the upper border of the stomach.

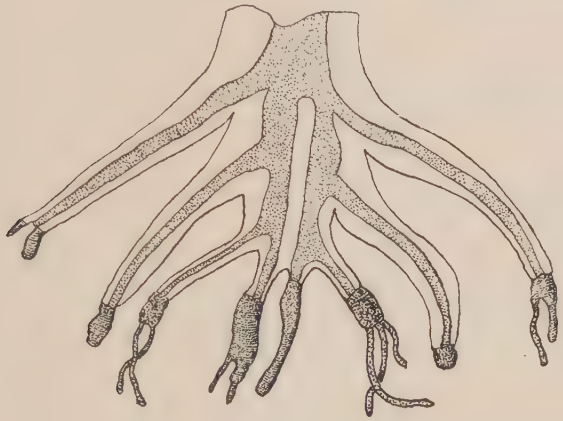
The 8 *gastric saccules* (Text-figs. 4 and 9), the most obvious and interesting character of this species, are wrongly figured in Mayer's side-view (1910 and 1917, figs. 331 and 4), but correctly in the oral view (figs. 331*c* and 4*c*, both identical). They are described by him as follows: " 4 pairs of gastric saccules arise from the per-radial sides of the stomach and project downward into the bell cavity. Each saccule is laterally flattened, cock's-combshaped, with an irregularly notched margin, and is about 20 mm. long and 11 mm.

* Perhaps the young " *Charybdea* spec." from Manokwari, New Guinea, with two rows of small tentacles on the larger ones may be a developmental stage of our medusa. The pedalia, however, of it have quite another shape. *Vide* my " Scyphomedusen ". Res. scient. du voy. du prince et de la princesse Léopold de Belgique dans les Indes Néerlandaises. Mem. Mus. Royal d'hist. nat., Bruxelles. Hors sér. vol. ii, 1930.

wide. A solid gelatinous projection extends downward so as to fill the greater part of the cavity of each gastric saccule." Light (1914, p. 197) gives a very brief but similar description—" each saccule is laterally flattened and cockscomb-shaped with an irregularly notched margin ".

Haeckel (1879, p. 44) described the saccules as small, egg-shaped and simple. The somewhat theoretical discussion of the gastric saccules by Thiel (1927, pp. 13–14) is hardly worth mentioning here, for he had no material in his own hands, and because he apparently has overlooked the description and the detailed figures of Mayer that show the strangely formed gastric saccules very distinctly, and furthermore, because he only speaks of the " eiförmige Gebilde " that is figured, rather erroneously, by Mayer in the middle of his large side-view of the entire animal.

In the present specimen the 8 saccules are about 35 mm. long and 15 to 20 mm. broad, and are situated on a short pedicle on the surface of the sub-umbrella on the per-radial



Text-fig. 8.

Text-fig. 9.

sides of the stomach. They are laterally flattened, irregularly lobed, hernia-like pouches, hanging freely in the bell cavity ; and in front view are more like the superficial hemispherical or finger-shaped outgrowths of malachite or limonite than a cock's comb in shape (Text-fig. 4). Their surface is formed by a thin whitish plain membrane that is almost entirely filled with a thick translucent cartilaginous jelly of the same form, but a little smaller. According to Mayer (1917, p. 191), they may occasionally be absent altogether.

The *gonads* are poorly developed, nearly transparent leaves, mostly, however, torn to pieces.

Colour.—The jelly is translucent, like crystal, with a very soft bluish hue ; all the inner organs are whitish-yellow and the rhopalia only show a brownish-yellow pigment.

The present specimen differs from the description by Mayer in various respects : in the velarium hanging down and not being stretched out like a diaphragm across the opening of the bell ; in the form of the sensory niches (?) ; in the number of tentacles and perhaps also in the number of the small appendages at the end of the tentacles ; and in the colour, there being no trace of a dull purple-pink coloration in the tentacles. I, however, believe both forms to be identical. It is, of course, not impossible that we may have here to do with quite another genus not known hitherto.

Order CORONATÆ Vanhoeffen, 1892.

Family PERIPHYLLIDÆ Haeckel, 1879.

Genus *Periphylla* Steenstrup, 1837.

Periphylla hyacinthina Steenstrup.

References :

Periphylla hyacinthina Steenstr., forma *dodecabostrycha*, forma *regina*, A. G. Mayer, 1910, pp. 544–547.
Periphylla hyacinthina Steenstr., G. Stiasny, 1934, pp. 343–365.

OCCURRENCE :

Station 18, Gulf of Aden near Berbera, 21.ix.33. 2-metre diam. tow-net, 900–0 metres (1500 metres of wire out).

3 specimens, forma *regina*, 80–100 mm. broad, well preserved, very deeply pigmented ; gonads feebly developed.

2 specimens, forma *hyacinthina*, without " Stielcanal ", 25 to 55 mm. broad.

Station 25, Gulf of Aden, near Cape Guardafui, 10.x.33. Agassiz trawl, 620 metres. (Some of the preserving fluid had leaked out, but about half was still left in the bottle.)

2 specimens, forma *dodecabostrycha*, 12 and 20 mm. broad, deformed, faded.

8 specimens, forma *regina*, 30 to 65 mm. broad, all flat, badly damaged, without stomach ; most specimens deeply pigmented, some with nearly the whole subumbrella covered with dark purple pigment ; gonads in all feebly developed.

Station 34, near Aden, 16.x.33. Agassiz net, 1022 metres.

12 specimens, forma *regina*, 35 to 82 mm. broad. Badly preserved and badly damaged ; pigment almost completely faded, 3 only with dark pigment ; gonads feebly developed.

Station 35, near Aden, 16.x.33. Otter trawl, 457–549 metres.

85 specimens, forma *regina*, 55–140 mm. broad. Flat, badly preserved, without stomach, most without gonads ; pigment markedly faded, some specimens nearly transparent, only the festoon on lappets and stripe in the middle of the same a dark purple ; larger specimens with ova. (In a brown fluid.)

1 specimen, forma *hyacinthina*, 45 mm. broad, with Stielcanal ; pigmented a dark purple.

Station 71, at the head of the Gulf of Oman, 26.xi.33. Otter trawl, 106 metres.

1 specimen, forma *regina*, 110 mm. broad ; better preserved ; with deep purple pigment on stomach, sub-umbrella and lappets ; gonads feebly developed.

Station 96, central part of the Arabian Sea, 19.xii.33. 2-metre diam. tow-net, 400–645 metres (900 metres of wire out).

1 specimen, forma *dodecabostrycha*, transitional stage to *hyacinthina*, 55 mm. broad. Well preserved, but somewhat damaged ; with rounded top and with " Stielcanal " ; stomach dark purple ; eggs visible from without.

Station 108, to the west of Pemba island, near Zanzibar, 13.1.34. Agassiz trawl, 786 metres.

1 specimen, forma *dodecabostrycha*, 32 mm. broad. Deformed, with "Stielcanal"; colour faded.

Station 121, Zanzibar area, 21.i.34. Agassiz trawl, in 925 metres depth, but net apparently not on the bottom.

2 fragments of the border of one or two large specimens, forma *regina*, 50 and 110 mm. broad. With pedalia, lappets and tentacles. Dark brown stripe in the middle of each lappet very broad; numerous large ova.

1 specimen, forma *dodecabostrycha*, 22 mm. broad. Very well preserved, with "Stielcanal"; very deeply pigmented; no gonads.

Station 176, Gulf of Aden, near Cape Guardafui, 2.v.34. Agassiz net, 655–732 metres.

37 specimens, forma *regina*, 34–100 mm. broad. Badly preserved, most without stomach; pigment faded, only a purple stripe on the lappets; gonads feebly developed or absent.

7 specimens, forma *regina*, 50–90 mm. broad. Better preserved than the others, mostly damaged; with more dark brown pigment on the muscles of the lappets and stomach; gonads visible on the two largest specimens only.

Station 185, Gulf of Aden, 5.v.34. Agassiz net, 2000 metres.

2 specimens, forma *regina*, ± 115 mm. broad. Flat, badly damaged; pigment faded with the exception of a dark purple radial stripe on the sub-umbrella side of each lappet; without gonads.

Station 186, Gulf of Aden, 5.v.34. 2-metre diam. tow-net, 952–0 metres (1500 metres of wire out).

50 specimens, forma *regina*, ± 85 mm. broad. Damaged; colour faded, festoon a yellow band; gonads well developed.

Station 193, near Aden, 7.v.34. Agassiz trawl, 1061 to 1080 metres (a repeat of Station 34).

55 specimens, forma *regina*, 25 to 130 mm. broad. Mostly damaged; almost without pigment; gonads developed in the largest specimens. Preserving fluid a deep brown colour.

The total number of specimens obtained was 237. The majority are flat, low domed, and of the *regina* type; 15 very small examples were of the *dodecabostrycha* type, and 3 only of the *hyacinthina* type (for these terms see my "Discovery" Report, 1934, p. 353). Most specimens are in a poor state of preservation in formalin, are badly damaged with the stomach, tentacles and lappets torn away and are deformed; many specimens bore traces of the bottom mud. The pigment has faded in nearly all and some are wholly transparent; in others the dark purple stripe on the underside of the lappets is the only poor remains of the original pigmentation. The specimens from Station 18 alone show fresh colours; in some of the jars the pigment had come out and the medusæ were found in a dark brown fluid. It may be that the Agassiz trawl is not very suitable for these catches, and that the specimens had been exposed for a time to direct sunlight before undergoing preservation. It is obvious that the flat *regina* type without "Stielcanal" can be recognized here even in small specimens of about 25 mm. breadth, although in my "Discovery" Report (1934) I have indicated 80 mm. as the minimum size for the forma *regina*.

There are very few specimens of the *hyacinthina* type, and the few of the *dodecabostrycha* type are from lesser depths. Most remarkable are the catches from the four Stations 35, 176, 186 and 193, which include by far the majority of the specimens.

On sorting out the plankton samples there was found from—

Station 172, Central part of the Arabian Sea, 29.iv.34. 2-metre diam. tow-net, 2091–0 metres (2665 metres of wire out):

1 specimen of *Periphylla hyacinthina* in the "Bigelow"-stage (*vide* my "Discovery" Report, 1934, p. 343); 12 mm. broad; no apical projection of the stomach into the mesoglœa; peripheral system entirely hyaline; stomach alone with dark brown pigment; somewhat deformed.

Distribution.—This medusa has previously been recorded from the Gulf of Aden, north and south-east of Cape Guardafui, north of Socotra, from various localities along the Somali coast and between the Seychelles and Zanzibar; but no specimen is known from the eastern part of the Arabian Sea, and only once has it been taken in the region between the Laccadives and India. The John Murray Expedition collected many specimens in the Gulf of Aden, near Cape Guardafui and south-east of it, some in the centre of the Arabian Sea and near Zanzibar; but not a single example in the eastern part of the Arabian Sea and only one in the Gulf of Oman. In the Red Sea *Periphylla hyacinthina* has never been caught. Where can the specimens in the Gulf of Aden have come from? For a discussion on this point see p. 238.

In the eastern part of the Indian Ocean this species has been recorded by Rao (a single specimen) from the Bay of Bengal. The medusa is, however, not rare in the Pacific Ocean in Philippine waters and in the Malay Archipelago, and it seems unlikely that it is in fact so rare in the Indian Ocean. If we consider the season during which the catches have been made, we see that the medusæ from Station 176, 44 specimens, Station 186, 59 specimens, and Station 193, 55 specimens, were collected in the Gulf of Aden in the month of May; the catches at Station 25, 10 specimens, Station 34, 12 specimens, and Station 35, 86 specimens, were made in October. In September and December only a few specimens were captured. By far the greater number of examples have thus been taken in May and October at the time of the change of the monsoons, and it seems possible that the seasonal changes may have a great influence on the appearance of these deep-sea medusæ.

Family Nausithoidæ Claus, 1878.

Genus *Nausithoë* Kölliker, 1853.

Nausithoë punctata Kölliker.

References:

A. G. Mayer, 1910, pp. 554–556, figs. 352–354.
For other references see below.

Occurrence:

Station 145c, east end of Kardiva channel, Maldive area, 1.iv.34. 1-metre diam. tow-net, 100–0 metres vertical haul.

1 specimen, 7 mm. broad. Deformed; gonads well developed with large ova; colour yellowish.

Distribution.—This cosmopolitan medusa, the range of which includes the tropical belts of all three large oceans, has been recorded previously by Bigelow (1901–4, p. 263) from the Maldives, by Browne (1905*a*, p. 154) from the waters off Ceylon, and later (1916*a*, p. 202) from the Chagos Archipelago and the Amirante Islands. Vanhoeffen (1903, pp. 29–30), in his " Valdivia " Report, mentions it from several localities along the East African coast and in the Gulf of Aden. In the plankton catches of the John Murray Expedition only a single specimen of this, usually so common, medusa was taken in Maldive waters.

The distribution of *Nausithoë punctata* seems to be restricted to the peripheral parts of the Arabian Sea, with the exception of the northern parts, whence it has not yet been recorded. It is, however, rather doubtful whether this medusa is in fact so rare in the Arabian Sea.

Family Atollidæ Bigelow, 1913.

(Synonym : Collaspidæ Haeckel, 1879.)

Genus *Atolla* Haeckel, 1879.

Atolla wyvillei Haeckel.

References :

A. G. Mayer, 1910, p. 566.
H. B. Bigelow, 1928, pp. 505–509.
G. Stiasny, 1934, pp. 366–379, pl. xv, fig. 4, text-figs. 3–6.

Occurrence :

Station 18, Gulf of Aden, near Berbera, 21.ix.33. 2-metre diam. tow-net, 900–0 metres (1500 metres of wire out).

6 specimens, *bairdii*-type,* 42–50 mm. broad. Deformed, strongly pigmented, all with well-developed gonads.

Station 25, Gulf of Aden, near Cape Guardafui, 10.x.33. Agassiz trawl, 620 metres.

1 specimen, *bairdii*-type, 55 mm. broad. Deformed ; pigment faded ; with gonads. (With many *Periphylla hyacinthina*.)

Station 34, Gulf of Aden, 16.x.33. Agassiz trawl, 1022 metres.

1 specimen, *bairdii*-type, 35 mm. broad. Gonads feebly developed ; colour faded, yellowish-green. (With many *Periphylla hyacinthina*.)

Station 35, Gulf of Aden, near Aden, 16.x.33. Otter trawl, 457–549 metres.

3 specimens, *verrilli*-type, ± 65 mm. broad ; with sharply indented border of central disk.

* *Vide* Bigelow (1928) and my " Discovery " Report (1934, p. 361). Three types of this species can be recognized, namely : (1) *bairdii*-type with a smooth central disc ; (2) *verrilli*-type with central lens scored with narrow furrows ; (3) *wyvillei*-type, central lens indented with broad deep radial furrows.

6 specimens, *bairdii*-type, 32–45 mm. broad; deformed; all nearly without pigment; gonads mostly well developed.

Station 98, central part of the Arabian Sea, 22.xii.33. 2-metre diam. tow-net, 2800–0 metres (vertical).

1 specimen, *bairdii*-type, 75 mm. broad. Very well preserved, but pigment faded; colour yellowish green; gonads nearly mature.

Station 121, near Zanzibar, 21.i.34. Agassiz net, in depth of 925 metres, but net probably not on bottom.

4 specimens, *bairdii*-type, 15–25 mm. broad. Colour faded; without gonads.

Station 172, Arabian Sea, east of Cape Guardafui, 29.iv.34. 2-metre diam. tow-net, 2091–0 metres (2665 metres of wire out).

4 specimens, *bairdii*-type, 12, 18, 28 and 62 mm. broad. All pigment faded and nearly transparent; oldest only with gonads.

Station 176, Gulf of Aden, 2.v.34. Agassiz net, 655–732 metres.

1 specimen, *bairdii*-type, 45 mm. broad. Transparent, colour greenish-yellow; gonads feebly developed. (With many *Periphylla hyacinthina*.)

Station 186, Gulf of Aden, 5.v.34. 2-metre diam. tow-net, 952–0 metres (1500 metres of wire out).

5 specimens, *bairdii*-type, 25–52 mm. broad. The three largest highly vaulted, 35 mm. high, with gonads; others flat, unripe. All faded, nearly without pigment. In one smaller specimen of 40 mm. breadth, the exumbrella is covered with a network of the central disk.

Station 193, Gulf of Aden, 7.v.34. Agassiz trawl, 1061–1080 metres.

1 specimen, *bairdii*-type, 22 mm. broad. Faded; without gonads. (With many *Periphylla hyacinthina*.)

In all 34 specimens were captured, most of which were of the *bairdii*-type, only 3 of the *verrilli*-type and none of the *wyvillei*-type. No example was taken of *A. chuni*, with glass-like beads on the lappets. All the specimens were faded; most were without pigment and nearly transparent or, on the whole, yellowish-green in colour with the ring-muscle an intense yellow-green. The gonads were but little developed.

Distribution.—Previous records of *Atolla wyvillei* are from the Gulf of Aden, to the south of Cape Guardafui, the Somali coast, between the Seychelles and Zanzibar, to the north-east of the Seychelles, the Chagos Archipelago, the Maldives and off Colombo; in every case a few specimens only. The John Murray collection comprises many specimens from the Gulf of Aden and near Cape Guardafui, and a few from Zanzibar and the central part of the Arabian Sea; no examples are from the northern part of the Arabian Sea or from the coastal waters of British India. *Atolla wyvillei*, therefore, seems to be restricted to the southern part of the western half of the Indian Ocean, with preference for the peripheral waters. Rao (1931) mentions a few specimens from the Bay of Bengal, the Laccadives and the Andaman Sea. There are no records of *Atolla wyvillei* from the Red Sea. It is strange that this medusa, that is known from the depths of all the oceans, should be relatively rare in the Indian Ocean.

Order SEMÆOSTOMEÆ L., Agassiz, 1862.

Family Pelagidae Gegenbaur, 1856.

Genus *Pelagia* Péron and Lesueur, 1809.

Pelagia noctiluca (Forskål).

References :

A. G. Mayer, 1910, pp. 572, 573.
H. B. Bigelow, 1928, pp. 517–520.
G. Stiasny, 1934, pp. 386–388.
G. Stiasny, 1935, pp. 14–16.

Occurrence :

Station 61, Northern part of Arabian Sea, off Karachi, 8.xi.33. 2-metre diam. tow-net, 2000–0 metres (2265 metres of wire out).

6 specimens, *panopyra*-type, 17–19 mm. broad. All yellowish-brown in colour, not translucent ; gonads developed in the largest specimen only. (Together with 4 *Halicreas*.)

Station 67, Gulf of Oman, near Muscat, 22.xi.33. Hand-net, surface.

13 specimens, *panopyra*-type, 17–42 mm. broad. Partly damaged ; whitish-yellow in colour ; gonads feebly developed. In some specimens very long tentacles, three times the diameter.

Station 73, Gulf of Oman, 27.xi.33. Hand-net, surface.

8 specimens, *panopyra*-type, 15–26 mm. broad. Well preserved ; whitish-yellow in colour ; gonads only in the largest specimen, pinkish in colour.

Station 87, West of Bombay, 7.xii.33. Agassiz trawl, 549–640 metres.

69 specimens, 15–35 mm. broad ; most of the *noctiluca*-type, some of the *panopyra*-type and a few only of the *cyanella*-type. Specimens deformed ; yellowish-white in colour ; gonads in all well developed, pink in colour.

Station 99, south-west of centre of Arabian Sea, 23.xii.33. Hand-net, surface.

1 specimen, *panopyra*-type, 25 mm. broad. Whitish-yellow in colour ; gonads well developed, pink coloured. (Together with 2 large *Æquorea*.)

Station 101, east coast of Africa, north-east of Mombasa, 27.xii.33. Hand-net, surface.

17 specimens, *panopyra*-type, 7–28 mm. broad. Well preserved ; yellowish-white in colour ; gonads feebly developed.

9 Ephyrae, 4 mm. broad, with short tentacles and one or two long gastric cirri only in each quadrant.

Station ?, Zanzibar area.

1 specimen, *panopyra*-type, 32 mm. broad. Yellowish-white in colour, opaque ; gonads well developed, yellowish-brown ; tentacles short and thick.

There are in all 115 specimens ; most of them are of the *noctiluca*-type, with the whole surface of the umbrella covered with elongated warts ; several are of the *panopyra*-type with rounded warts, and a few only of the *cyanella*-type with a smooth marginal zone (see Bigelow, 1928).

Most specimens were caught with the hand-net at the surface. The two catches, from Station 61 with the 2-metre diam. tow-net from 2000–0 metres and from Station 69 with the Agassiz net at 549–640 metres, when 69 specimens were obtained, are remarkable. It may be that in each case the medusæ were caught during the last moment of the haul ; but it is, however, not impossible that both catches were from major depths. Similar hauls were effected by the " Snellius " Expedition in the Malayan Archipelago (Stiasny, 1935, p. 15). It is, therefore, not improbable that *Pelagia noctiluca*, a typical surface medusa in moderate latitudes, descends in tropical waters to major depths.

In the plankton samples the following developmental stages were found :

Station 96, central part of the Arabian Sea, 19.xii.33. 1-metre diam. tow-net, 10–0 metres (14 metres of wire out).

8 post-ephyral stages, 3–5 mm. broad. Deformed ; brownish-yellow in colour. Together with some hydromedusæ.

Station 76, Gulf of Oman, 29.xi.33. 1-metre diam. tow-net, 200–0 metres (300 metres of wire out).

2 post-ephyral stages, 8 mm. broad. Badly preserved ; colour whitish, transparent.

Distribution.—*Pelagia noctiluca* has hitherto been recorded from the Somali coast, Zanzibar, east of Zanzibar, west of the Seychelles, the Chagos Archipelago, the Maldives and the Gulf of Manaar, as well as from the South Indian Ocean. It is rather astonishing that this very common medusa has not previously been taken in the northern part of the Arabian Sea or in the Gulf of Aden. The John Murray Expedition collected it in the central part of the Arabian Sea, near Zanzibar, in the northern part of the Arabian Sea and in the Gulf of Oman ; so this gap is now filled. Rao (1931) mentions one specimen from an unknown locality in the Indian Seas, and Menon also records the species—the actual number of specimens is not indicated—from the waters off Madras. It is a very common form in the Philippine Archipelago and in Malayan Waters (*vide* Mayer [*P. panopyra* Pér. & Les., 1917, p. 199] and the author [1935, pp. 14–16]).

Pelagia noctiluca may be regarded as being distributed all over the Indian Ocean and the Arabian Sea. It is curious that the John Murray Expedition did not collect a single specimen in the eastern part of the Arabian Sea and in the Maldive and Laccadive waters, in a region where this medusa has in the past been recorded repeatedly.

Descriptive Notes by Lt.-Col. R. B. Seymour Sewell.—In the freshly-caught examples of this medusa the gonads are rose-pink in colour, and so are the four sub-umbrella tentacles ; the marginal tentacles are also coloured rose-pink in their proximal parts, but the colour fades to yellow at the extremities.

At Station 101 during the morning and at mid-day there was very little plankton to be seen at the surface ; but towards the late afternoon, from 3.30 p.m., the amount increased very considerably. At 9 a.m. a single example of *Pelagia noctiluca* was seen, but in the evening a number were caught and many more could be seen beyond the range of the hand-net. Associated with these medusæ were small black Amphipods ; it was rare to capture a medusa without taking one at least of these Amphipods, whereas one could

sweep the net through the water for several minutes without capturing one. So there seems to have been a definite association.

Genus *Sanderia* Goette, 1886.

Sanderia malayensis Goette. (Pl. I, figs. 1, 2 and 3; and Text-fig. 10).

References :

A. G. Mayer, 1910, p. 590.
E. Vanhoeffen, 1903, p. 38, taf. iii, fig. 12; taf. viii, figs. 69–74.
E. T. Browne, 1926, pp. 110–112.
G. Stiasny, 1935, pp. 18, 19.

Text-fig. 10.

Occurrence:

Station 25, Gulf of Aden, near Cape Guardafui, 10.x.33. Hand-net, surface; from a clump of Sargasso weed.

1 specimen, 63 mm. broad. Badly damaged; colour whitish-yellow; gonads brownish-yellow, not transparent, almost mature. Their papillæ lie very irregularly one upon another. The stomach pouches (Text-fig. 10) show on their sides in the neighbourhood of the border of the umbrella, both in the tentacular and rhopalar areas, strangely formed lobes or outgrowths, that alternate with deep sinuses. The tentacular pouches protrude distally farther into the lappets than do the rhopalar and they are larger and broader; the latter become very narrow and protrude, as small digitiform outgrowths only, into the rhopalar lappets. The lappets are still plain, but a later fission is indicated by an outward incision. Above the rhopalium there is a small flat smooth groove. Exactly in the middle of both pouches the entoderm shows a longitudinal fold; above the rhopalium this fold bifurcates and gives rise to an appearance as of a bifurcating vessel running to the rhopalium; but this is not the case; it is a fold only of the entoderm lamella. In the tentacular pouches a similar fold runs to the root of each tentacle but does not bifurcate there.

Station 61A, northern area of the Arabian Sea, off Karachi, 8.xi.33. 1-metre diam. tow-net, 1000–0 metres (1136 metres of wire out).

2 developmental stages, both in the *Pelagia*-stage, 10 and 15 mm. broad, 7 and 5 mm. high, with 8 marginal sense-organs, 8 tentacles, 16 cleft marginal lappets and 16 peripheral stomach pouches, very similar to those captured by the " Snellius " Expedition in the Malayan Archipelago (*vide* Stiasny, 1935, pp. 18, 19) (Pl. I, fig. 2). Both were very obviously flattened at the top, as if they had been cut off, with a conical elevation in the centre and large round transparent warts all around it. Manubrium very long, ± the radial length ; tentacles also ± the radial length. Genital ostia bordered externally by very few folds, the latter forming finger-shaped papillæ. Colour yellowish-white, stomach and tentacles opaque white.

Station 75, Gulf of Oman, 28.xi.33. Hand-net, surface.

27 younger and older ephyræ, 3–5 mm. broad (Pl. I, fig. 3).

These are the youngest stages of development that are so far known of this medusa. The smaller ones are flat, nearly transparent, finely granulated on the ex-umbrella ; tentacles = ± diameter) ; the gastro-vascular system is opaque white and is distinctly visible. The larger examples are mostly vasiform, manubrium long (± the radial length), still without gastric cirri ; the peripheral system yellowish-white, and the rhopalia without pigment. Most of the specimens are slightly damaged at the border. There are some abnormalities to be seen ; one specimen possessed 36 stomach pouches, 18 tentacles and 18 rhopalia ; a second specimen had 28 stomach pouches. In another example the septum between two adjacent stomach pouches is forked. Similar abnormalities have been observed by previous authors.

Station 76, Gulf of Oman, near Muscat, 29.xi.33. 2-metre diam. tow-net, 2500–0 metres (2800 metres of wire out).

5 specimens, 35, 38, 45, 47 and 55 mm. breadth ; flat. Colour greenish-yellow without any trace of pigment. Surface of ex-umbrella covered with small granules. At the apex the small papillæ are highest, the border of the ex-umbrella being nearly smooth. Lips of mouth 2 diameters in length. tentacles 3 diameters in length. The tubular œsophagus is, in most specimens, about the length of the radius, as was the case in the specimens collected by the " Snellius " Expedition in the Malayan Archipelago (*vide* Stiasny, 1935, pp. 18–19). The tentacles are somewhat thickened at the base and taper to long hair-like threads, which reach almost three times the diameter in length. They are much thinner than the ribbon-like broad tentacles of a specimen, not very much larger than the present, that was described by Vanhoeffen from the Gulf of Aden. They are a little compressed laterally. The gonads in the smaller specimens are visible only as small finger-like fringes, arranged in the form of an arch or crescent. In the older and better preserved specimens the finger-shaped papillæ have grown longer (Pl. I, fig. 1) ; they are far less regularly arranged, one next the other, than is figured by Vanhoeffen (*vide* his, in other respects, excellent figure, pl. viii, fig. 69), and do not form a heart round the

subgenital ostia, but a broad horse-shoe, the inner ends of which are widely separate and which fuse with the next in the narrow interspaces.

In my "Snellius" Report (1935, pp. 18–19) I have recently discussed this species with reference to some specimens from the Malayan Archipelago. The present examples agree with the Malayan in that in both cases pigment is completely absent, and no trace is to be seen of the fine yellowish-brown stripes on the ex-umbrella that were observed by Vanhoeffen in living specimens taken by the "Valdivia" Expedition (*vide* his pl. iii, fig. 12).

Distribution.—This medusa was caught many years ago by the "Valdivia" in the Gulf of Aden (Vanhoeffen, 1902, p. 37), and has more recently been recorded by Browne (1926) in the material of the Suez Canal Expedition, which contained 30 specimens. Other records of it from the Indo-Pacific area are from Singapore (Goette), the Malay Archipelago (Stiasny) and the Philippines (Mayer), in each case a few specimens only. The localities of the John Murray Expedition are Cape Guardafui, Gulf of Oman and off Karachi —relatively numerous localities for this rather rare medusa. Five specimens were caught with 2800 metres of wire out; they most probably did not, however, come from the deeper depths, as this medusa is known to be a typical surface form. The specimen from Station 25 was, apparently, attached to a clump of Sargasso weed; the tentacles are, in fact, exceedingly glutinous, and if they are touched with a pencil or needle one cannot easily get rid of them. It is striking that not a single specimen of this medusa was caught in the eastern half of the Arabian Sea, as was to be expected according to all previous records. On the contrary, two localities are situated in the Gulf of Oman and a third in the northern part of the Arabian Sea; no specimen was collected in the waters of the Maldive, Laccadive and Chagos Archipelagos.

Family Ulmaridæ Haeckel, 1879.

Sub-family Aurelinæ L., Agassiz.

Genus *Aurelia* Péron and Lesueur, 1809.

Aurelia maldivensis Bigelow.

References:

H. B. Bigelow, 1904, p. 261, pls. vi, viii, figs. 22, 23, 27.
G. Stiasny, 1935, pp. 32, 33, fig. 8.

Occurrence:

Station 41, South Arabian coast, Kuria Muria Islands, 27.x.33. Hand-net, surface.

2 specimens, (i) badly damaged, colour whitish-yellow; (ii) 130 mm. broad, colour pinkish.

Station 99, Central part of Arabian Sea, 23.xii.33. Hand-net, surface.

4 specimens, 120–140 mm. broad; mature, colour yellowish-white.

Station ?, Zanzibar Harbour, 25.i.34. Hand-net, surface.

2 specimens, 120–170 mm. broad. Badly preserved, colour yellowish-white, nearly mature.

Station 131d, southern area of Arabian Sea, east of the Seychelles, 11.ii.34. 1-metre diam. tow-net, 500–0 metres vertical haul.

1 specimen, 70 mm. broad. Very transparent, colour yellowish-pink, with many abnormalities in the gastro-vascular system. Gonads feebly developed.

All nine specimens show, as did those described by me in the report on the "Snellius" medusæ (1935, pp. 32–33), the mouth-arms strongly thickened in the proximal parts and irregularly twisted ; the lips broad. The colour, however, does not agree ; the present specimens are not lilac or reddish-brown, but yellowish-white or pinkish. In most specimens the gonads were mature.

Distribution.—The species, *A. maldivensis*, is recorded by Bigelow from the Maldives and by me from the Red Sea (Port of Perim), and recently from the south cape of the Sinai Peninsula. *Aurelia maldivensis* has been collected by the John Murray Expedition in the central part of the Arabian Sea near the Seychelles, in the waters off Zanzibar and near the Kuria Muria islands. It was not taken by the expedition in the eastern part of the Arabian Sea nor near the Maldive and Chagos Archipelagos—localities where previously most specimens of the form have been caught.

Notes by Lt.-Col. R. B. Seymour Sewell.—On October 8th, 1933, to the east of Ghubbet Minna, off the Somali coast, in a depth of 138 fathoms a number of examples of a species of *Aurelia* drifted past the ship ; the species was thicker in the umbrella than *Aurelia aurita* and was possibly *A. maldivensis*. They were of a delicate mauve or purple-blue colour, with the gonads showing up in darker colour than the rest of the animal.

On October 31st, off Ras Madraka on the south-east coast of Arabia the surface plankton was very rich, and included a number of examples of *Aurelia* of apparently the same species as before. Further specimens were seen on the surface on December 23rd at Station 99, and nearly 50% of the medusæ were accompanied by a small fish.

On January 25th and 26th, 1934, while at anchor in Zanzibar Harbour the expedition again encountered this medusa ; there were literally thousands present at the surface and, where they were drifted against the ship's side by the wind, there were hundreds that were actually touching each other, so close were they packed. Swimming backwards and forwards at a slightly greater depth than the medusæ were numerous small fish, and these could be seen to dart in under the umbrella of the medusa and then dart away again. In cases where the medusa had descended to a slightly lower level than that of the general shoal, several of these little fish could be seen around the same medusa, apparently busily engaged in feeding on the medusa itself. Quite a number of examples that were captured and examined had had their tentacles damaged, and in some cases these were actually non-existent, apparently eaten away by the small fish. In life these medusæ were of a delicate mauve or purple-blue colour, with the gonads showing up in a darker colour than the rest of the animal. When ripe the gonads are of a rose-pink colour that is not confined to these organs, but is also seen in the radial canals and still more markedly in the marginal tentacles.

By the 29th the number of *Aurelia* present had greatly diminished, though there were still large numbers to be seen drifting past the ship.

Mr. O. M. Latter informed me that while he was on the way out to Colombo in the Orient liner " Orford " a shoal of medusæ, of apparently the same species, was encountered off the Somali coast, both before and after passing Cape Guardafui, on February 5th and 6th, 1934.

Order RHIZOSTOMÆ Cuvier, 1799.

Sub-order KOLPOPHORÆ Stiasny, 1921.

Section ACTINOMYARIÆ Stiasny, 1921.

Family CEPHEIDÆ Stiasny, 1921.

Genus *Netrostoma* Schultze, 1898.

Netrostoma cœrulescens Maas.

References :

O. Maas, 1903, pp. 35–38, pl. v, figs. 37–46 ; pl. xi, figs. 97, 103 ; pl. xii, fig. 109.
E. T. Browne, 1905, pp. 967–970.
M. G. K. Menon, 1930, p. 13, pl. ii, fig. 7*a–d*.

OCCURRENCE :

Station 75, Gulf of Oman, Strait of Hormuz, 28.xi. 33. Otter trawl, 210 metres.

1 specimen, 90 mm. broad. Badly damaged on the border, mouth-arms torn away. Muscle-rays strong, gastro-vascular system visible here and there (type *Cephea*, sub-type *Netrostoma*, with 3 inter-rhopalar canals) ; colour bluish, transparent.

This is a surface form, caught here by the open otter trawl ; the depth, 210 metres, is remarkable.

DISTRIBUTION.—Very common in Malayan and Philippine waters, but seldom taken in the Indian Ocean. Browne reports the species from the Maldive waters and Menon from Madras. In the western parts of the Indian Ocean and the Arabian Sea this medusa has not previously been captured ; it is, therefore, not uninteresting that the John Murray Expedition obtained one specimen so far north in the Arabian Sea as the Straits of Hormuz.

Genus *Cephea* Péron and Lesueur.

Cephea sp. (Text-fig. 11.)

References :

A. G. Mayer, 1910, p. 651*a*, *f*.
E. Vanhoeffen, 1902, pp. 45, 46, and pl. iv, figs. 13 and 14, for *C. cœrulea* Vanh.
M. G. V. Menon, 1930, p. 12.

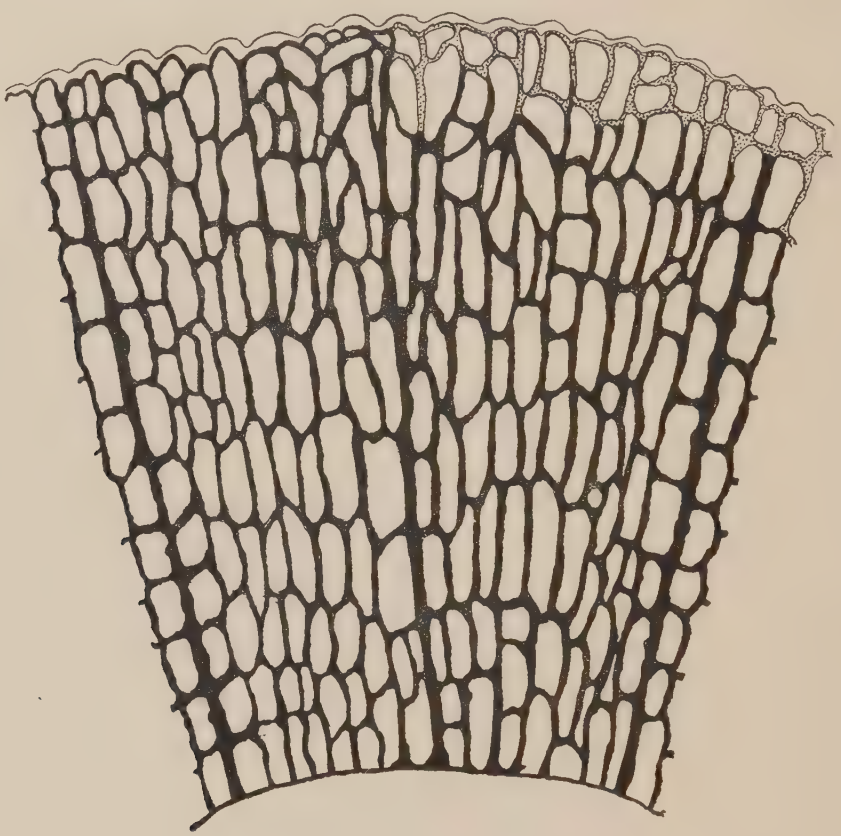
OCCURRENCE :

Station 61A, northern area of Arabian Sea, off Karachi, 8.xi.33. 2-metre diam. tow-net, 2000–0 metres (2265 metres of wire out).

1 specimen, 260 mm. broad, damaged ; with numerous fragments of another specimen.

REMARKS.—The large specimen is badly damaged ; there is only the umbrella with a gaping hole in the centre, a part of the border and the stomach ; the remainder, including the arms, has been torn away. The whole disc is thin and weak, and is of a yellowish-brown colour. The muscles are obviously feeble ; the meshes of the gastro-vascular system are, however, faintly visible. I could not detect a single sense-organ on the border

(Text-fig. 11). The lappets are small, rounded, similar in appearance and regular in form. In the canal system 16 slightly broader canals are indistinctly visible between the finer mesh-work. Nowhere could I find any incisions for the niches of the sense-organs. Not being able, however, to recognize the rhopalia, I was unable to distinguish the rhopalar from the inter-rhopalar canals. All vessels anastomose immediately after leaving the stomach. The number of canal-roots may be 6 or 8. Text-fig. 11 is of a rather schematic character and is to be regarded merely as a sketch, drawn to give an impression of the



Text-fig. 11.

canal system. It may be that we have to do here with a new type of canal system, all other known species of the genus *Cephea* having 8 principal radial canals only. I, however, cannot say anything with certainty regarding this point. Very obvious is the extremely feeble development of the muscles. In Actinomyariæ the muscle-rays are commonly very strongly developed ; but in the present specimen, on the contrary, hardly any trace of musculature can be seen.

The surface of the ex-umbrella is covered with irregular, polygonal, flat humps, separated by shallow furrows ; near the border the surface is smooth.

In the numerous fragments of the second specimen the jelly is somewhat stronger, more resistant and of a greyish-blue colour. There are only fragments of the umbrella without lappets or sense-organs. The muscles here, too, are poorly developed. The mesh-work of the anastomoses of the gastro-vascular system is of yellowish-brown colour, and shows a similar pattern to that of the first specimen.

The specimen was hauled with the 2-metre diam. tow-net from the remarkable depth of 2000 metres. The species of *Cephea* being, however, known to be typical surface medusæ, the specimen was, perhaps, caught in the last moment of the haul.

I dare not attempt to determine the species to which this specimen and the fragments may belong ; and I have even considered the possibility that I might be dealing with a species of the genus *Cassiopea*, that is well known from these waters. The type of the network, however, conforms with certainty to the *Cephea*-type, but the feeble development of the muscles does not agree with the strong muscle-rays so typical, otherwise, of the Actinomyariæ. It is possible that this is a specimen of *Cephea cœrulea* Vanhoeffen, that was taken by the " Valdivia " Expedition near Dar es Salaam ; this latter species possesses 8 rhopalia and 7 inter-rhopalar canals, but, according to the description of Vanhoeffen (1903, p. 46), has very strong radial muscles. It is most unfortunate that both specimens are in such a bad state of preservation that a more accurate study and determination is impossible.

Distribution.—This genus has only twice been recorded in the literature from the Indian Ocean, namely, *Cephea cœrulea* by Vanhoeffen from Dar es Salaam, and a mutilated specimen of a *Cephea* sp. by Menon (1930, p. 12) from the waters off Madras.

Sub-order DACTYLIOPHORÆ Stiasny, 1921.

Family Catostylidæ Stiasny, 1921.

(*Partim* Lychnorhizidæ Uchida, 1926.)

Genus *Crambionella* Stiasny, 1921.

Crambionella orsini (Vanhoeffen) Stiasny. (Pl. I, figs. 4 and 5 ; Text-figs. 12, 13 and 14.)

References :

Mastigias orsini E. Vanhoeffen, 1888, pp. 34, 35, pl. iv, figs. 2–4.
Crambionella orsini G. Stiasny, 1921, p. 129.
Crambionella orsini G. Stiasny, 1922*b*, p. 55.
Crambionella orsini G. Stiasny, 1923, pp. 232–235, fig. 2*a–c* ; fig. 3*a–c*.
Crambionella orsini M. G. K. Menon, 1930, p. 18, pl. iii, fig. 14*b* and *d*.

Occurrence :

Station ?, anchorage off Ras Khabbah, south-east coast of Arabia, 4.xi.33. Hand-net, surface.

6 specimens, smallest 55 mm. broad, largest 90 mm. broad. Well preserved, but the mouth-arms in every case torn away.

The gastro-vascular system plainly conforms to the *Crambione*-type. The arm-pillars are very broad, nearly three times as broad as the narrow slit-like, crescent-shaped sub-genital ostia. The colour is a uniform yellowish-brown, and one specimen, of 65 mm. breadth, shows a broad dark brown border ; the rhopalia bear no pigment ; they are all whitish and are very clearly visible between the surrounding darkly pigmented parts of the border. The long deep furrows, that run in a vertical direction to the border between the lappets, are whitish. All lappets are transparent, and some show the beginning of fission. Gonads in all specimens feebly developed.

Station ?, anchorage, Muscat, 22.xi.33. Hand-net, surface.

1 specimen, 72 mm. broad, 28 mm. high. Well preserved, but the mouth-arms badly damaged. Arm-pillars only twice as broad (20 mm.) as the ostia. The " arcade " of the network is always isolated, very high, hanging down so as to reach the border of the stomach. Colour, on the whole, bluish ; on the border of the ex-umbrella a broad violet zone ; lappets translucent, without pigment ; rhopalia whitish. On the border of the ex-umbrella many deep long furrows.

Station 70, off Jask, Gulf of Oman, 25.xi.33. Otter trawl, 196 metres.

1 specimen, 110 mm. broad, 43 mm. high. Colour uniformly brownish-yellow, only a little darker towards the border ; lappet zone transparent ; rhopalia without pigment. Mouth-arms bluish-yellow. Appendages about half the length of the under-arm.

Text-fig. 12.—(For comparison with Pl. I, fig. 4.)

Station 71, Straits of Hormuz, 26.xi.33. Otter net, 106 metres.

1 specimen, 88 mm. broad, 46 mm. high. Colour bluish-yellow with a pale violet border zone, upper arms with a pale violet hue. Appendages varying from $\frac{1}{3}$ to $\frac{1}{4}$ the length of the under-arm.

Station 75, Straits of Hormuz, 28.xi.33. Otter net, 201 metres.

3 specimens : (1) 90 mm. broad, 42 mm. high ; (2) 110 mm. broad, 40 mm. high ; (3) 115 mm. broad, 45 mm. high. One specimen uniformly light violet ; along the border two pigment zones of different colours, above a narrow circular stripe with irregular smaller or larger dark violet spots, often somewhat faded, and on the border a narrow dark violet ring with broad and deep white wedge-shaped furrows between and white furrows on the lappets ; lappets and rhopalia without pigment. Both the other specimens are much less pigmented ; the ex-umbrella is yellowish-brown, with a dark brown-violet ring-zone and pigmentless rhopalia and lappets. The mouth-arms are bluish-yellow ; the appendages are quite translucent with the canal-system distinctly visible. The gastro-vascular system (Text-fig. 14) is in all three specimens obviously strongly developed. The anastomoses are formed by unusually broad vessels, and look as though they had been injected with a whitish-yellow milk-like fluid. In the mesh-work of each arcade 3 or 4 canals, running radially and vertically to the ring-canal, are very obvious ; they are either all broader than the other lateral anastomoses, or are alternately thicker and thinner canals. In the extra-circular net 16 to 18 long canals, running vertically to the ring-canal, are

distinctly visible between the rhopalar canals. The terminal appendages on the mouth-arms are very variable in length. In the darkly pigmented specimen with dark spots they are quite rudimentary ; in the others so thickly covered with frills that a very small part only of the appendage remains naked. In one specimen they are about one-third of the length of the under-arm. Some of the mouth-arms are extremely short, only half as long as the others.

Station 76, off Muscat, 29.x.33. 2-metre diam. tow-net, 2500–0 metres (2800 metres of wire out).

3 specimens : (1) 85 mm. broad, 32 mm. high, well preserved ; (2) 70 mm. broad, 28 mm. high, well preserved ; (3) 72 mm. broad, 32 mm. high, without appendages. Gastro-vascular system typical, with very narrow network. Arm-pillars in all much broader than the ostia ; arm-disc very thick and high, in one specimen a vertical column of about 20 mm. high,

Text-fig. 13.

that is very similar to a patagium. Muscles very strongly developed, circular, interrupted in the rhopalar radii. Appendages of the mouth-arms very variable, plump, blunt pyramids, very short or nearly as long as the under-arm. Much less deeply pigmented than the examples from Ras Khabbah or the anchorage at Muscat ; the largest specimen of a yellowish-violet hue with a broad bright violet zone on the border ; lappets and rhopalia translucent. Mouth-arms and appendages yellowish. The other two examples greenish-violet, with a broad, pale, dull violet zone along the border ; mouth-arms, mouth-frills and appendages yellowish.

2 specimens : (1) 70 mm. broad, 35 mm. high. Under-arms rudimentary (not damaged), without appendages ; very pale brownish-yellow, with two pigment zones, the upper pigmented uniformly dark brown, the lower with smaller or larger irregular dark brown spots.

(2) 82 mm. broad, 48 mm. high. Brownish-yellow ; a strongly pigmented brownish-violet circular zone along the border, lappets and rhopalia translucent. Appendages approximately the same length as the under-arm. The gastro-vascular system of this specimen shows several abnormalities

(Text-fig. 13). From left to right there are (1) a fine meshwork, deep, hanging on one side of the rhopalar canal; (2) a normal network, somewhat extended on the right side; (3) an oblique inter-rhopalar canal debouching into a sinus-like enlargement of the ring-canal, from which arises a long blind outgrowth running obliquely towards the stomach; (4) a rhopalar canal bearing on each side a deep, fine-meshed network; (5) a forking inter-rhopalar canal, sending out a curved branch parallel to the border of the stomach towards the adjacent rhopalar canal and two stronger radial branches towards the ring-canal, all united by a dense irregular network of anastomoses; (6) a rhopalar canal connected in many places with the mesh-work. In three adjacent sectors a canal-system typical of *Catostylus* is represented. The other sectors show the typical high and isolated network (arcade), sometimes narrow, sometimes broader.

Measurements of one of the specimens:

Breadth of umbrella	105 mm.
Height of umbrella	52 ,,
Breadth of arm-disc	59 ,,
Height of arm-disc	21 ,,
Breadth of sub-genital ostia	22 ,,
,, of arm-pillars	31 ,,
Length of mouth-arms	62 ,,
Length of end-knob	25 ,,

Descriptive Notes.—The descriptions of this medusa by Vanhoeffen and Menon are not exhaustive, and in many respects are unsatisfactory. The present fresh material is in an excellent state of preservation, so that the descriptions can be completed, especially as regards the colour.

Jelly of the Umbrella.—*Crambionella orsini* is a plump, massive medusa, the jelly of which is opaque, hard and cartilaginous. A similar condition is present only in certain species of the genera *Catostylus* and *Stomolophus*. *Crambione* is always weak and tender, and is nearly transparent.

Size.—The size of the John Murray specimens, 55–110 mm. broad, is large in comparison with Vanhoeffen's type-specimen (65 mm.; *vide*, however, my observations on it, 1922, p. 232, footnote), but small in comparison with the measurements given by Menon. In the waters off Madras *Crambionella orsini* attains a breadth of 210 mm.

Border of the Umbrella (Pl. I, fig. 4, and Text-fig. 12).—The surface of the ex-umbrella is in most specimens finely granular, not plain, as stated by Vanhoeffen; the short pointed velar lappets are, however, smooth and number 16 in each octant. The rhopalar lappets are also plain, but are shorter, more pointed and diverge. Each velar lappet fuses above, *i. e.* towards the apex, in a relatively high thick ridge that is separated from the neighbouring one by a broad deep furrow of 5–6 mm. in length. On these ridges runs a wedge-shaped gully. On each side of the latter is a narrow ridge. Both ridges converge above each lappet, but do not reach the lappet itself. I have not previously observed this strange sculpturing (1922, text-fig. 2*c*), and neither has Menon seen it (1930, pl. iii, fig. 14*b*). The furrows between the lappets are always without

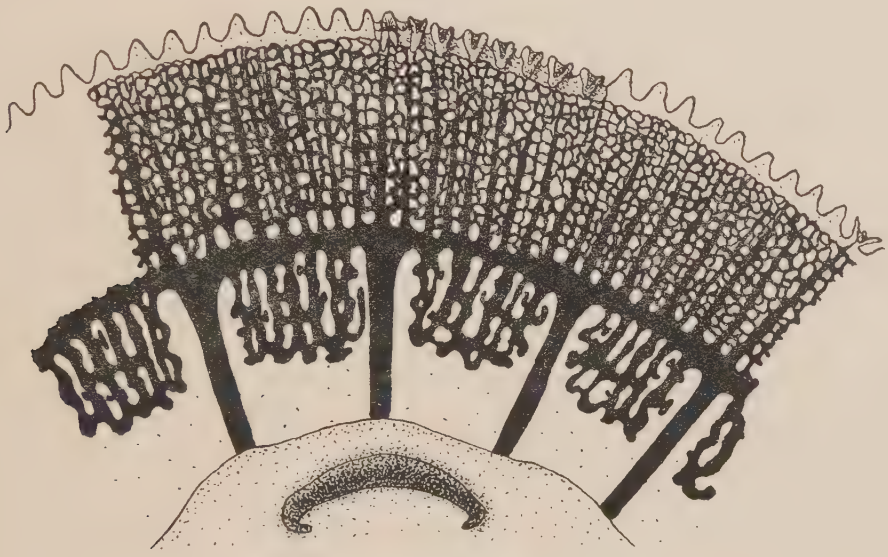
pigment and are, therefore, like the rhopalia, very obvious in the middle of the surrounding dark pigment. The rhopalia are separated from the adjacent velar lappets by slightly broader and deeper furrows. The sensory groove lies upon a rather thick slipper-shaped elevation of the jelly that extends upwards into a broad round ridge.

The *arm-disc* is very thick, massive and high, and sometimes resembles a patagium; the upper arms, however, never fuse with it, but always remain free.

The *sub-genital ostia* have a very typical shape; they are crescent-shaped slits, strongly narrowed by the thickened under-lip; there are no subgenital papillæ. (Text-fig. 14).

The *muscles* are strongly developed, circular, interrupted in the rhopalar radii.

The *gastro-vascular system* (Text-fig. 14) in most specimens shows the typical *Crambione* type. The arcade is often very high, so long as to reach nearly to the border of the



Text-fig. 14.

stomach. In some specimens (for instance that from Station 75) the intra-circular network is strikingly well developed. Between the meshes there are 3 to 4 thicker radial vessels which run vertically to the ring-canal, or there are thicker and thinner canals alternating. In the extra-circular network of anastomoses there are, too, in each sector, numerous—16 to 18—radial canals running from the ring-canal to the periphery. The lappets are always free from network and there is no distinct peripheral ring-canal. The roundish warts, observed by me between the intra-circular network of the type-specimen (1922, p. 232, text-fig. 2B), could not be seen here. One specimen exhibited abnormalities of the gastro-vascular system (*vide supra*, p. 233, Text-fig. 13).

The mouth-arms.—Between the mouth-frills of the ab-axial side there are no appendages to be seen. On the axial side, however, there are small transparent buttons, mostly arranged in rows, in conformity with Vanhoeffen's description; none, however, occurs above the terminal appendage. The terminal knobs vary extremely in shape and length. They are either almost rudimentary, their whole surface being covered with frills, or they may be almost as long as the under-arm, or only a half to a quarter the length of the same.

In all individuals the gastro-vascular system of the mouth-arms is distinctly visible owing to its whitish canals and anastomoses.

The *gonads* are in all the present examples very poorly developed.

Colour.—Menon, who had the advantage of studying the fresh colours of living specimens, records only a bluish-green. The present specimens, however, show a great variability of coloration ; some are very strongly and darkly pigmented ; others on the contrary are very pale. There are the following varieties :

(*a*) The ex-umbrella uniformly yellowish-brown with a broad dark brown band along the border.

(*b*) The ex-umbrella bluish-green with a broad dark violet zone along the border.

(*c*) The ex-umbrella pale yellowish-violet with a pale violet zone along the rim.

(*d*) The ex-umbrella uniformly pale violet with, towards the border, an upper narrow band of irregular, larger or smaller, deep violet or faded spots and a lower zone towards the lappets of a uniform dark violet colour.

The *sensory pits* and *radial furrows* on the border of the ex-umbrella are always very pale and without pigment ; the zone of the lappets is translucent.

The *mouth-arms* are yellowish-brown, rarely with a violet hue on the mouth-frills of the under-arms.

Some of the more deeply pigmented specimens remind one of the coloration shown in the beautiful figure of *Stomolophus meleagris* given by Mayer (1910, pl. lxxv, fig. 1).

Distribution.—*Crambionella orsini* has been recorded from Assab in the Red Sea (Vanhoeffen) from a few specimens only, but it is very common in the waters off Madras (Menon). It was, therefore, quite unexpected to find a relatively large number of this rare medusa in the John Murray hauls from localities so far north in the Arabian Sea as Muscat in the Gulf of Oman and in the Straits of Hormuz. The presence of this form at these widely separated localities cannot at the moment be explained satisfactorily (*vide* my remarks on p. 239, *infra*). All the specimens of *Crambionella orsini* from the Gulf of Oman were captured in the month of November at the surface, the only exception being the catch from Station 76 from 2000–0 metres depth. According to Schott (1918, pp. 10–12, table 2 ; and 1935, p. 214) there is, during the winter months (October–March), an outflowing surface current passing in a south-easterly direction out of the Persian Gulf into the Gulf of Oman. It is therefore not impossible that the specimens of *Crambionella orsini* captured in November in the Gulf of Oman may have had their origin in the Persian Gulf.

Rao (1931, pp. 50–55, pl. iii, pl. iv, fig. 1, text-figs. 4–8) described a new species of the genus *Crambionella*, *C. annandalei*, from the Andaman Sea. I, however, do not believe that this can be accepted as a good species. It agrees with *C. stuhlmanni* in respect of the tubercles on the velar lappets ; but, according to Rao, differs from it " only in the great length of the terminal club and its tapering form and in having small foliaceous appendages among the mouth-frills ". The present material of *C. orsini*, however, shows clearly to what a high degree the clubs may vary, and hence this feature cannot be regarded as a good character—a decision that also accords with my experience of *Mastigias* and *Acromitus*. The foliaceous appendages thus remain as the last difference between the two forms. The colour of the living animal is not recorded by Rao, but in the preserved condition it is a pale pink or cream. In view of these facts I cannot but regard *C. annandalei* as a doubtful species.

The very inaccurate description by Chun of *Crambessa viridescens* from the Pangani River, East Africa, is based on badly damaged specimens and, in fact, rests solely on the colour sketch by Stuhlmann (Chun, 1896, plate, fig. 2), that shows the umbrella to be of a vivid pale green (" seegrün ") colour and the mouth-arms pale with a light violet hue on the mouth-frills (the whole border having been torn away). Mayer (1910, p. 670) and the author (1921, p. 142) have recorded this medusa under the name *Catostylus viridescens*. The thorough study of the type-specimen, carried out by me (Stiasny, 1922*b*, pp. 49–50), was a very unsatisfactory one because of the bad state of preservation. From my study of the present material I believe that *Crambessa viridescens* Chun is a mutilated *Crambionella orsini*. Menon records the bluish-green colour of the bell in the living animal, and the present specimens are greenish too.

The old type-specimen, when I examined it, was greyish-yellow. The end-knobs are occasionally absent, as we know also in the case of *Mastigias* and *Acromitus*. The shape of the subgenital ostia, the very broad arm-pillars and the absence of subgenital papillæ agree perfectly with the present specimens. I thought, it is true, that I could recognize in the type-specimens, though not without some hesitation on account of the bad state of preservation, the canal type of *Catostylus*. Furthermore this medusa, *Crambessa viridescens*, was recorded from the Pangani River, which would be in accordance with my view.

? *Crambionella stuhlmanni* (Chun), recorded by Menon (*loc. cit.*, pp. 18, 19, pl. iii, figs. 14*a–c*) from the waters off Madras, is only an abnormal example (9 rhopalia, 14 velar lappets with conical outgrowths on the dorsal median line of the velar lappets) of *C. stuhlmanni*.

In conclusion I am inclined to adopt the view that there are only two good species in the genus *Crambionella*, namely, *C. stuhlmanni* (Chun), with a row of tubercles on the velar lappets, and *C. orsini* (Vanhoeffen) without tubercles, but with deep furrows on the lappets (the first species has knobs on the mouth-arms, while the second is with or without foliate appendages between the mouth-frills)—a difference that reminds one of *Atolla chuni* and *A. wyvillei*, that are respectively with and without glass-like beads on the velar lappets.

SOME REMARKS ON THE RELATION OF THE HYDROGRAPHY TO THE DISTRIBUTION OF THE SCYPHOMEDUSÆ IN THE ARABIAN SEA.

The Arabian Sea, with the exception of the Gulf of Aden and the Gulf of Oman, is, so far as its hydrography is concerned, almost unexplored (*vide* the splendid work of Schott, 1935, ' Geographie des indischen und stillen Ozeans '). For the hydrography of the two gulfs I refer the reader to papers by Schott (1918 and 1929), and to the publications of O. Krümmel (1911), F. Vercelli and M. Picotti (1927), D. Matthews (1927 and 1928), Raphael del Buen (1927), A. Puff (1890), Luksch (1900), and Van Riel (1932).

With the exception of some short preliminary communications by Lieut.-Col. R. B. Seymour Sewell, the leader of the Expedition, published during the course of the expedition or soon after its return (*vide* the Bibliography at the end of this paper), the hydrographical results of the John Murray Expedition have not yet been published. Very little, therefore, can be said regarding the relationship between the hydrography and the distribution of the medusæ in the Arabian Sea in general; and it is impossible to compare, as I had

hoped to do, the Scyphomedusan fauna on the north east and south-west sides of the Carlsberg Ridge that obviously divides the area into two different faunistic regions. Perhaps this may be done later. The two concentrations of medusæ, however, in the Gulf of Aden and the Gulf of Oman are so obvious and interesting that I feel obliged to try to give at least a preliminary explanation of the origin of both.

From the geographical point of view these two gulfs are very different. The Gulf of Oman is in open communication with the shallow Persian Gulf throughout from the surface to the bottom *viâ* the narrow Straits of Hormuz. No transverse ridge separates the two areas, the Straits of Hormuz being a deep fissure in the Oman chains that permits the transport of the entire water-column from the surface to the bottom into the Persian Gulf from the Gulf of Oman and *vice versâ*. The deep Red Sea, on the contrary, is tectonically shut off from the Gulf of Aden ; north of Bab el Mandeb, near Great Hanish Island, there is a submarine threshold of about 100 metres in depth only. The currents in the Gulf of Oman are relatively simple, but in the Gulf of Aden we have to do with an extremely complicated system of currents caused by numerous submarine ridges on the floor of the sea, besides the seasonal changes in the direction of the currents caused by the monsoon and the tides.

In the Gulf of Oman there is during the months October to March an outflowing surface current, extending down to 30 to 70 metres, by means of which the water-masses are transported from the Persian Gulf *viâ* the Straits of Hormuz into the Gulf of Oman (*vide* Schott, 1918, table 2, p. 10 ; and Sewell, 1934, p. 669).

In the Gulf of Aden we find hydrographical conditions that are similar to those of the Straits of Gibraltar. According to the experience of Rafael del Buen (1927, p. 60) in this region we have, perhaps, to assume that the western deep current from the Red Sea is bent upwards before reaching the shallow sill near Great Hanish Island and runs backwards into the Red Sea again. From the Gulf of Aden surface water of relatively low salinity runs through the Straits of Bab el Mandeb into the Red Sea in compensation for the loss caused there in consequence of the extremely strong evaporation. At 100 to 150 metres' depth cooler water, but still warmer than 21° C., of about 39 to 40°/$_{oo}$ salinity flows over the threshold into the Gulf. This component of the deep water-current entering the Gulf of Aden from the west is most probably very feeble and sinks in the Gulf down to 500 to 1000 metres' depth, exercising its influence, however, as far as the middle of the Gulf (Schott, 1935).* The hydrographical results of the John Murray Expedition, however, indicate that conditions had become reversed in the different cruises in spring and autumn (*vide* Sewell, 1934, pp. 137–138). In the Gulf of Aden itself a number of serial water samples and temperature readings indicate " a very complicated system of vertical rotation in the water-masses " in consequence of the ten transverse deep sea ridges in the Gulf.

Considering all these circumstances it seems rather improbable that the *Periphyllas* caught by the John Murray Expedition in the Gulf of Aden could have had their origin in the depths of the southern parts of the Red Sea, and that they had been carried out with the feeble outflowing deep-sea current. Moreover, neither *Periphylla* nor *Atolla* have been recorded hitherto from the Red Sea, and these medusæ being cold-water forms or forms

* The abnormally high temperatures below the surface in the Arabian Sea have been attributed to this source (Matthews, 1927, p. 512).

of moderate temperatures, it is extremely improbable that they will in the future be recorded from the warm deep waters of the Red Sea (*vide* also this Report, p. 220 and 222). So little, however, is known of the Scyphomedusan fauna of the Red Sea, and especially of its southern parts, that we cannot say with certainty whether the absence of the medusæ here is a fact, or is only apparent owing to the imperfect exploration of this area.

The occurrence of *Atolla* and *Periphylla* in a nearly continuous series of localities from Zanzibar along the East African coast to Cape Guardafui may, however, give a hint for another explanation of the origin of the medusæ in the Gulf of Aden. There is in this region, in the months August and September (Schott, 1935, table xxx), a strong current running in a north-east direction in consequence of the strong permanent winds, but restricted to a narrow stream along the coast, with small branches to the right due to the deviation caused by the rotation of the earth. In compensation cool water from the depths wells up towards the surface. To this cold upwelling water, perhaps, the presence of the cool-water medusæ in these coastal waters may be due. Both forms are recorded from Cape Guardafui too. It seems not impossible that a part of the deep-sea medusæ in the Gulf of Aden may have come from the south along the East African coast, carried along by the northward flow of the Socotra current, and have entered the Gulf between Socotra and Cape Guardafui (*vide* Puff, 1890, map 1).

It is rather improbable that the *Periphyllas* and *Atollas* of Zanzibar may be of antarctic origin. Sewell (1925) has shown that from the far south three large branches of antarctic water run very far north into the Arabian Sea. The western branch, however, is shown as ending in the latitudes of Madagascar, but Wüst (1934) has brought forward evidence to show that this deep bottom current can be traced up the African coast as far north as lat. 10° N.

Another possibility is, of course, that the medusæ in question may have originated in the Gulf of Aden itself and near Cape Guardafui. Most of the specimens of *Atolla* and *Periphylla* captured here are immature, with gonads but poorly developed. They must, therefore, have had their birthplace in the neighbourhood of these localities, and it is rather improbable that they can have undergone a long transport.

With regard to the medusæ in the Gulf of Oman, most of which were caught in November on the surface, it may be that they have been carried along with the south-east current coming from the Persian Gulf and that they have originated in this shallow sea. We know nothing at all, however, about the medusan fauna of this shallow area.

It is to be hoped that the publication of the hydrographical results of the John Murray Expedition will provide the required data for a more satisfactory and decisive explanation of the distribution of the medusæ in the Arabian Sea in general, and in both Gulfs in particular. There are still other interesting biological problems to be solved, for which, however, further exhaustive hydrographical data are indispensable. For instance, is it not strange that *Sanderia malayensis* suddenly appears in relatively large numbers near Suez, off Karachi and in the Gulf of Oman, this medusa being common in Philippine waters and the Malay Archipelago, and having hitherto been recorded only once in the Gulf of Aden ? Another problem is the sudden occurrence of *Crambionella orsini* in the Gulf of Oman, this medusa having been previously recorded in the waters off Madras and once only near Assab in the Red Sea ! Why is *Periphylla hyacinthina* apparently restricted to the western part of the Arabian Sea, and has never been recorded near the Maldives, Chagos Islands and the Seychelles, and only once from the Laccadives ; and whence comes the

relatively rich medusan fauna near Zanzibar ? Are its deep-sea components endemic, or are they carried by an eastern or southern current to and along the South-African coast ? This question is extremely interesting in view of the presence of the subtropical convergence just north of Zanzibar.

Finally the central part of the Arabian Sea shows some striking characteristics with regard to its hydrography. In the eastern part to the east of the Carlsberg Ridge there is a marked deficit of oxygen, that is already remarkable within a few metres of the surface. In depths of 500 to 600 metres there is a high salinity of about $35{\cdot}5^{\circ}/_{\circ\circ}$ that is nowhere else recorded from similar depths in the Indian Ocean ; and during summer there is, in adaptation to the strong prevailing south-west wind and in accordance with the configuration of the coast, a monsoon current that runs clockwise round the central part of the Arabian Sea (*vide* Schott, 1935, p. 219, and pls. xxix and xxx).

Perhaps these facts, and others that may be deduced later on from the hydrographical results of the John Murray Expedition, may provide a more satisfactory explanation of the poorness of animal life in the central part of the Arabian Sea, that seems comparable in some respects with the condition present in the Sargasso Sea in the North Atlantic Ocean. Is it not obvious that most localities where medusæ occur are arranged along the periphery of this area, or is this merely a coincidence, and to be attributed to the comparatively small number of hauls that have been made in this region ? The central part of the Arabian Sea is likely to have, not only its own hydrographical character, but also its own rather poor fauna, and one that is somewhat different from that of the adjacent waters.

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DESCRIPTION OF PLATE.

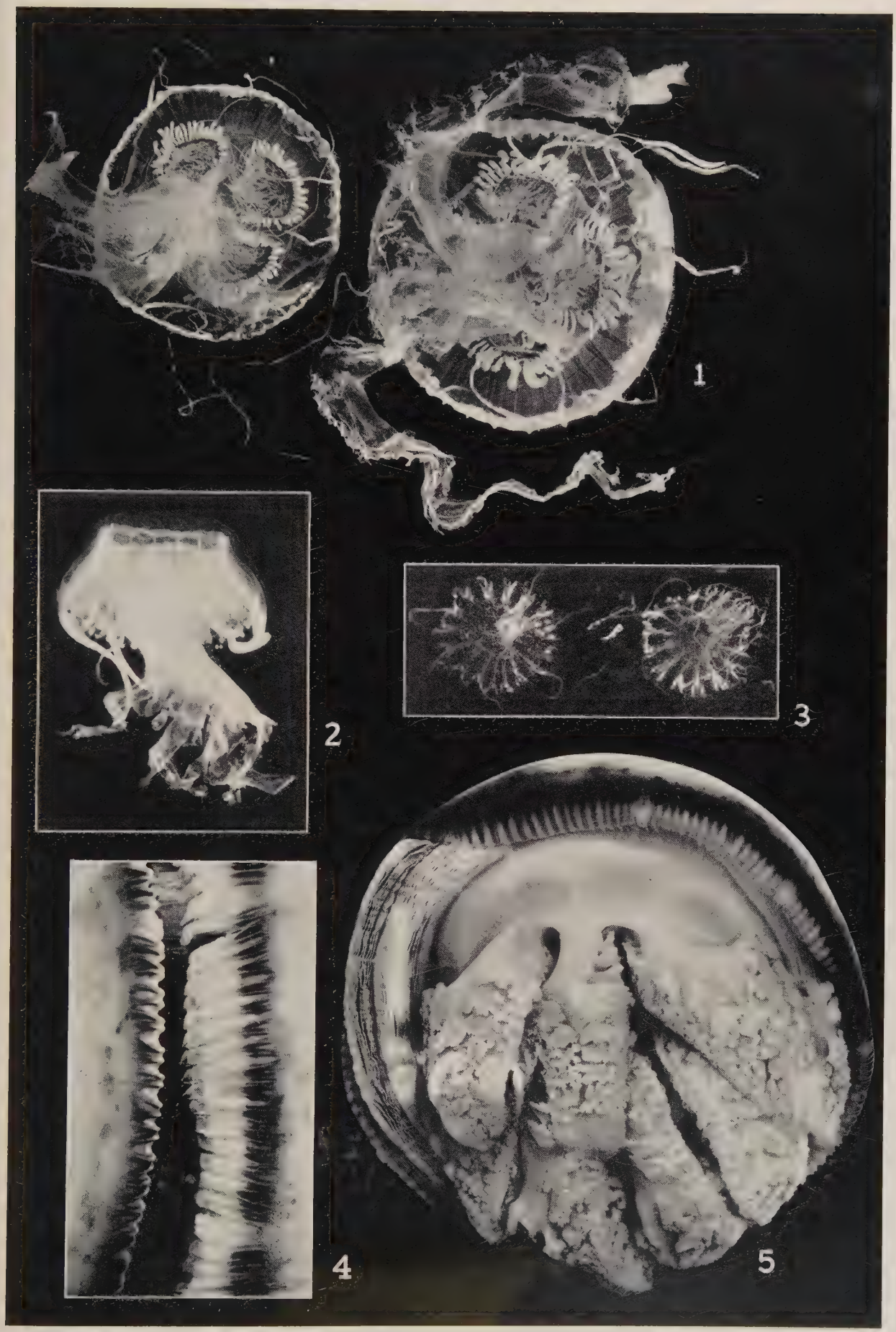
Fig. 1.—*Sanderia malayensis* Goette. Natural size. Sub-umbrellar view.

Fig. 2.—*Sanderia malayensis* Goette. *Pelagia*-stage. Side view. × 3.

Fig. 3.—*Sanderia malayensis* Goette. Post-ephyral stages. × 5.

Fig. 4.—*Crambionella orsini* (Vanhoeffen) Stiasny. (On the left sculpture on the lappets, on the right furrows between and form of the lappets.) × 5.

Fig. 5.—*Crambionella orsini* (Vanhoeffen) Stiasny. Sub-umbrellar view. Natural size.



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